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PAPERS

read at the

Smoke Abatement Conferences

March 26, 27 & 28, 1912

With Discussions

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LIST OF PAPERS.

Notes on the Action of Coal Smoke on Building Stones and Mural Paintings.

(By Sir Arthur Church, K.C.V.O., D.Sc., F.R.S., F.S.A.)

Five years ago I delivered, at the Royal Institution, a discourse on some means of defending building stones and mural paintings against the attack of coal smoke. Now I purpose dealing briefly with the nature of this attack. To do this coal smoke must be defined, or at least described. It forms a part but does not constitute the whole of the products of the imperfect combustion of coal. It contains gases and vapours, liquids and solids. From the present point of view three of these of minor importance, namely, water-vapour, carbonic acid, and that portion of coal ash or mineral matter which is carried mechanically in the upward current of smoke, need not detain us. But the case is different with the rest of the chief constituents of coal smoke. These may be conveniently grouped under the three headings—carbon, tar, and sulphur compounds. All these things, including even moisture and coal ash, are present in soot, which may be regarded as the obvious and concrete part of coal smoke. But some of these things—those which can exist as vapours—although present in soot, are present also in part between the soot-particles, and in course of time become diffused into the general atmosphere or are washed out of it by falling raindrops, in which they are soluble. But before this diffusion, or this washing out by rain occurs, and while the smoke is cooling, considerable absorption, by the soot, of the vaporised and gaseous constituents of the smoke takes place. It is then and in this way that the soot becomes charged with injurious matters, notably with several sulphur-compounds. We may now proceed to submit the soot itself to a rough kind of analysis. Let us first subject a portion to a moderate heat—that of boiling water. First a little moisture comes off, accompanied by traces of sulphurous acid, and of volatile hydrocarbons, such as are found in coal tar. On raising the temperature salts of ammonia and of compound ammonias are now set free, with indications of the presence of sulphur compounds, in one of which the sulphur exists in an unoxidised condition. Whatever the exact nature of this compound may be, it acts upon metals in the same way as ammonium sulphide, blackening silver and imparting a ruddy tarnish to copper and its alloys. On further

increasing the heat to which our sample of soot is being subjected its less volatile constituents are liberated, the chief of these being what we may term tarry matter. Of the residue ultimately left by far the greater part is carbon, amorphous carbon or lamp black, a substance endued with considerable powers of absorbing and retaining many gases and vapours. We now proceed to raise the temperature of the residue ; the carbon takes fire and burns away, leaving a decided quantity of ash or mineral matter.

It may be affirmed that whatever be the injurious effects of the carbon and mineral matters in smoke upon the processes and functions of organic nature, it is not to these constituents, were they unaccompanied by other substances, that the damage done by coal smoke to building stones, to mural paintings, and to objects of metal can be attributed. They soil and disfigure, but they do not, *per se*, corrode and disintegrate or alter. The offending constituents of soot are those which are associated with, having been absorbed by, the carbon which forms its basis. The tarry matters before mentioned impart a measure of stickiness or adhesiveness to the solid particles, and stain the surface, be it stone, or paint, or metal, in a way which needs special treatment with appropriate solvents to effect a true cleansing. But these tarry matters can be dealt with easily because they do not change the nature of the surface which they soil—they form a removable addition—removable, that is, where the solvent used to remove them does not also remove the varnish, the pigments, the patina. It is otherwise with the group of sulphur compounds present in soot. It was calculated several years ago, by Dr S. Rideal, that the sulphur present in the coal then annually burnt in London gave rise to an amount of oxidised sulphur compounds corresponding to half-a-million tons of sulphuric acid, that is oil of vitriol. That was the minimum amount, but it might reach twice that quantity. Think of this—at least half-a-million tons of sulphuric acid poured every year into the London atmosphere ! It is true that when coal is burnt under ordinary conditions some sulphurous acid is first formed. But this compound soon oxidises into sulphuric acid, which is the chief destructive agent present in urban atmospheres. I might cite many instances of decayed stonework to prove this point, analysis of samples from buildings in Oxford, Canterbury and London. For instance, the outer face of the Sheldonian Theatre at Oxford contains no less than 19 per cent. of gypsum, all, save the veriest trace, formed from carbonate of lime by the attack of atmospheric sulphuric acid. Magdalen College tower gave me more than 11 per cent. The interior walling of Westminster Chapter House contained just 18 per cent. of the same product, while St. Paul's Cathedral furnishes a most striking instance of the destruction wrought by the sulphuric acid in London air and rain. There is a blackish stalactitic incrustation hanging to the under side of the cornice

above the colonnade and below the dome ; this is some inches deep in places, and contains nearly 74 per cent. of gypsum, or hydrous calcium sulphate. Whence did this deposit derive its sulphuric constituent if not from the sulphuric acid washed out of the London air by falling rain ? But I am not dealing now with London air and London rain, but with London and urban soot. Yet the same injuries from the same hostile agents may be traced to soot, because it is a carrier of acid, and, resting a while upon a corrodible surface, has time to perform its destructive work. I may add here that soot, falling upon some stones other than those which contain or consist of calcium carbonate, exerts upon them also a destructive action. If granite and other allied stones practically escape corrosion, stones like serpentine, of which the main part is a hydrous magnesium silicate, are rapidly corroded, soluble magnesium sulphate being formed to be washed away in the first shower.

We may now very briefly consider the effect of coal smoke on mural paintings. Putting aside the blackening of lead-compounds which should be excluded from the palette, it is here once again that sulphuric acid is the chief culprit where paintings in true fresco are concerned. The delicate film of calcium carbonate upon and within the layer of pigment is transformed into gypsum, expanding from 10 volumes to 12 and losing all binding power. Even the painting-ground, that is the lime plaster beneath the picture, is often affected and rendered rotten. There is, however, one advantage which fresco enjoys in comparison with the methods of oil and spirit fresco, namely, that when besmirched with tarry matter from soot and smoke, this discolouration may be removed without interfering with the pigments. Convenient solvents for this purpose are furnished by methylated spirit, by toluol, and by " painting " petroleum.

Allusion has already been made to the effect of one of the constituents of coal smoke upon certain metals, the tarnishing of silver and the discolouration of copper and its alloys. We may leave out of consideration, since means (not always successful) of protecting this metal from corrosion are invariably adopted. But to show how the most solid gilding fails to preserve the metal to which it has been applied from corrosion, I may cite the gilt bronze screens at either end of the reredos at St. Paul's. These have been subjected to an atmosphere polluted with sulphurous acid escaping from stoves burning coke in the basement of the Cathedral. Modern research has shown how difficult, how well-nigh impossible, it is to form an absolutely non-porous and continuous coating of one metal upon another. If cracks and other breaks in continuity are at first imperceptible, yet the unequal expansions of the two metals, in consequence of temperature-changes, may soon develop them. In some such way one may account for the thick bluish-green crust, containing copper sulphate, which disfigured the gilt bronze

grilles or gates in St. Paul's. Here, of course, the corrosive atmophere was primarily at fault, and only in a less degree particles of soot; still the action in both cases was similar. To protect pictures and objects of art, wherever possible by means of glazing or by seclusion in glass cases, is a sound precaution. Thus the amount of corrosive bodies and of acrid soot which can come in contact with the surfaces to be protected is greatly restricted, while, on the other hand, the free circulation of a vitiated atmosphere about and around our artistic treasures is always bringing fresh supplies of noxious matters into contact with their susceptible surfaces.

These notes aim at no completeness; I shall be glad if they stimulate inquiry and discussion, and if they serve to correct some misconceptions. Finally, I am bound to utter one caution: abatement of the smoke nuisance, or even its entire abolition, however great the advantages to health and comfort, and the amenities of life which it will bring, cannot get rid of the injury and pollution caused by sulphuric acid.

The Influence of Smoke on Decorations.

By Noel Heaton, B.Sc., F.C.S.

I take it that the nature of smoke and the cause of its corrosive action is fully understood by the members of this Conference, and that it is merely necessary to remind you that the most potent factors in its destructive action are the sulphur compounds produced by the combustion of coal.

It should be clearly recognised that the actual smoke is not the primary agent of decay, and that the smoke resulting from the combustion of fuels which are entirely free from sulphur, such as wood, is *comparatively* innocuous. At the same time the smoke decidedly acts as a *contributory* cause of decay.

With this preface I propose to examine the actual effect in specific cases which have come under my practical experience. This is most marked in the case of the exterior of buildings, the fabric of which is exposed to the direct action of the atmosphere. The corrosive effect of our modern atmosphere on the carved stone and statuary of our churches is self-evident, and in many buildings which I have been called upon to examine with a view to advising some method of preservation and restoration, I have found the whole substance of the stonework decayed owing to the conversion of the original limestone into sulphate of lime.

But confining our attention in the present paper to the effect on decorative work, I will refer first of all to the matter of windows. Stained glass should be little affected by smoke if properly executed. The gradual decay of the glass which is so noticeable in old windows is due to several causes, and although these are decidedly aggravated by contamination of the atmosphere, there is no real excuse for the premature decay one notices in some modern windows, which are due to the use of improper materials and the improper use of materials.

Both the glass and the enamels used in properly executed modern windows are extremely resistant to decay, and the constant change of temperature necessitated by our modern needs in the way of warmth and light are far more potent factors in decay than smoke, the effect of which is practically limited to the dimming effect of the actual dirt.

I pass now to the question of the effect on the exterior paintwork of houses. The National Association of Master House Painters recently conducted a series of practical tests of paints which, although designed for a rather different purpose, provide some direct information on this question.

Briefly stated, the experiment consisted in painting a series of panels with six different white paints, prepared with different pigments. A large number of sets of these panels, each prepared in exactly the same manner, were distributed amongst the local branches of the Association throughout the country and exposed as far as possible under identical conditions for two years. They were then submitted to me for examination and report as to their condition.

The full report was published in the *Journal of Decorative Art*, last November, and whilst it cannot be looked upon as in any way final, as this test is merely a preliminary to a more extended series, the general conclusion one arrives at is that smoke is by no means the most potent factor in the actual disintegration of the paint film, which takes place more rapidly in the pure air and bright sunshine of the seaside than in our great cities. The smoke of a large town, of course, rapidly obscures the paintwork and renders it unsightly, but *as far as the film is concerned* this dirt often adheres so closely that it acts as a protective coating, and when the dirt is removed the painted surface underneath is found to be in good preservation.

We must remember, however, that a surface of oil paint is by no means impervious to moisture, and smoke may under such conditions exercise a very insidious destructive action on the pigments mixed with the paint and the surface which the paint film is intended to protect whilst *leaving the paint itself undamaged.*

The action in this case is somewhat as follows :—The coating of soot on the paint, deposited from smoke, is very porous and acts in the manner of a sponge, keeping the surface bathed in moisture. This moisture, which in a smoke-laden air is really a dilute solution of sulphuric acid, gradually penetrates through the film of paint and attacks the surface behind, so that in the case of metal or stone, decay often goes on under the paint, which finally peals off, revealing an undreamt of state of corrosion behind it.

There is also in many cases an action on the pigments in the paint. White lead, for instance, which forms an almost universal ingredient in paint for exterior use, is rapidly decomposed by sulphuric acid, and gradually turns black in the event of any of the sulphur being present in the state of sulphuretted hydrogen, which is generally the case. Here we get a permanent discolouration of the paint as the indirect result of smoke which no cleaning will remove.

It is really this indirect action of smoke in acting, as it were, as a collector and carrier for the destructive agencies that is its chief menace to decorative work. We must not blame smoke for everything, and must realise that if all smoke were entirely abolished the amount of sulphuric acid discharged into the air would be just as great so long as coal combustion continued,

and also that the impurities in the air of great cities not due to fuel at all would be just as great.

The point which thoroughly justifies the agitation in favour of smoke prevention, however, is that in the absence of smoke the effect of the presence of these impurities in the air would be minimised. Every smut which lodges on a building, though harmless in itself, acts as a carrier for the moisture charged with the products of combustion which are the active agents of destruction.

In the case of internal paintings we find that the decay attributable to smoke assumes greater proportions, as such paintings are protected from what one may call the normal effect of weather. The same remarks apply, as regards the decay of the paint film, as in the case of external paintings—the necessity for frequent cleaning, with its attendant dangers, is the most noticeable evil, but in course of time the film is permeated by the acid charged moisture ; the darkening of the varnish and oil of an oil painting, which frequently leads to its entire obliteration, is largely due to the action of these impurities on the lead generally dissolved in the vehicle to assist the oxidation or "drying," as it is termed, and may to a large extent be prevented by care and experience in the selection of proper materials. In the case of pictures, the same remarks are applicable, only with greater force.

But the effect of smoke is more clearly felt in the case of works of art which form the permanent decoration of a building. In order to be seen properly in the comparatively dim light of an interior, mural paintings must be clean, and in a smoky atmosphere constantly depositing dirt this necessitates constant washing. The smooth, varnish-like surface which alone will resist the adhesion of dirt and admit of being washed without mechanical injury is, however, extremely objectionable in a work of mural painting decoration ; and, on the other hand, the matt absorbent surface which enables the design to tell to the best advantage, offers such a foothold for dirt of the adhesive nature derived from smoke that it is practically impossible to clean it efficiently.

Decay of the *pigments* of a mural painting should not fairly be attributable to smoke, however, for it is quite possible to execute any internal painting or decoration with pigments that are perfectly stable and proof against attack, *given sufficient technical knowledge and experience on the part of the artist.* White lead, for example, can be entirely replaced by zinc oxide in such paintings, and work can to a large extent be carried out with such pigments as iron oxide and natural earths, which are perfectly stable against sulphur and acids.

When we consider paintings executed on the plaster of the wall itself, either in oil or tempera, the effect of smoke is more disastrous, for the active agents of corrosion pass through the

paint in the way I have described and attack the plaster behind, with the result that one frequently sees such paintings peeling from the wall in places owing to the disintegration of the surface of the plaster.

The destructive effect of smoke is, however, seen at its worst in the case of fresco paintings, for here we have of necessity a surface composed almost wholly of carbonate of lime in a porous condition, to which the dirt adheres so tenaciously as to be almost impossible to remove, and which is, moreover, attacked by the dilute acids in the same way as limestone, only more readily, because of its comparatively soft condition.

Under normal conditions fresco is the most permanent as well as the most beautiful form of decorative painting, but under modern conditions some preservative treatment, such as impregnation with wax, which inevitably results in the loss of some of its charm, is absolutely necessary to protect it from rapid decay. It is scarcely too much to say, in fact, that the smoke nuisance has in towns rendered the execution of a satisfactory and permanent work of decorative painting one of the most difficult problems of applied chemistry.

On these grounds alone, the preservation of our buildings and works of art, apart from the great question of public health and welfare, the reduction of the smoke nuisance is a problem that should engage the earnest attention of everyone who has at heart the beauty and comfort of our great cities.

The Effect of Coal Smoke on Buildings.

By Harry Redfern

(Fellow of the Royal Institute of British Architects).

I am given to understand that my views on the practical effect of coal smoke on buildings is what is wished for, and that the subject will be dealt with in its chemical aspect independently.

Of course the whole question of the effects resulting from coal smoke is fundamentally one of chemistry ; and it is hardly possible to treat of the troubles to which buildings are subject without touching upon the chemical side. My remarks, however, will be confined as closely as may be to the purview of the practising architect. For any incursion into the field of chemistry, to which I may be drawn by the development of my theme, I would plead for the leniency of those who are masters of that science ; and I take this opportunity of acknowledging the great help I have received from my friend, Mr. Mintore Taylor, in the preparation of this paper.

(1) The architect, then, knows very well from experience that if he builds in the country, right away from towns, his building, from the time it is finished, begins to improve in appearance, and so long as it stands continues so to improve ; for Nature, if left alone, harmonises everything with herself. On the other hand, nowadays, he knows, alas, that if he builds in a town his building never looks so well as when it is just finished. I say nowadays, because in the days when only wood, charcoal, or peat was used, this was not the case, for the deposit from wood fuel encourages vegetation.

(2) Legal prohibition of the use of sea coal in towns continued in force up to the middle of the sixteenth century, and any transgression of the law was visited by severe penalty. The preambles to the various restrictive enactments bear witness to the fact that they were brought about by the defilement of buildings caused by coal smoke, and particularly in respect of that to the whitewash—with which in the Middle Ages buildings were universally treated—and to the colour decoration which very generally was applied to the street front of buildings. By the lapse of these Acts, limewhite and pure colour little by little

disappeared from towns; and so at length they came to take on the dingy, sooty, and dejected aspect which they now present; for, alas, the use of either pure white or colour is impracticable in the towns of to-day.

(3) Let us consider for a moment the effects of this inability to use pure colour. Delight in colour is a human birthright. Nature supplies to mankind in abundance the means for the gratification of his colour sense. Various considerations cause tracts of land to be smothered with buildings, extirpating the natural features of the landscape and the vegetation, and screening from view most of the colour of the heavens, and all of that which lies about the horizon. Save for a bit of the sky, natural terrestrial colour is thus almost entirely wiped out. Scientists tell us that for the disuse of the exercise of a physical function, Nature invariably and inexorably claims a penalty; and that man always is guided by instinct to endeavour to supply by artifice anything which by nature he should have, but which for any reason is lacking to him. So in towns—as in rooms—the exercise of his function of colour vision on natural features being impossible, man instinctively makes an effort to supply the deficiency by applying to the surfaces of his buildings fresh and bright colours, low toned in large masses and high toned in small, but always luminous. For many years now, however, the effort has been abandoned in despair. In towns to-day no colour, however bright or highly glazed, will keep its purity for more than a brief season.

It is interesting to speculate how much of the nerve trouble now so prevalent amongst town dwellers, ascribed now to this and now to that stress, and again to deprivation of pure light or pure air, or what not, may be due to deprivation of pure colour.

(4) For the architect, then, coal smoke makes pure colour effects impracticable, and for the expression of his art he is confined, both in mass and detail, to play of light and shade and variety of outline.

But even in these means of expression he is by the curse of coal smoke very straitly limited. The world has become so accustomed to the blight of soot, that it is with some astonishment that it receives the statistics recently published by the Coal Smoke Abatement Society, showing the magnitude to which the evil had attained. In the City of London no less than 650 tons of soot fall per annum on the square mile. To the architect, however, the news came as no surprise, but rather as a reduction into terms of figures of a thing of which he had been always conscious, a thing which constituted a serious factor among the many things which impose restrictions upon his use of the means of expression of his art, building materials; a thing, moreover, with which he had always to contend in framing the practical details of the construction of his buildings.

(5) Mr. Thackeray Turner informs me that when some years ago scaffolding was put up round the Church of St. Martin's-in-the-Fields, in Trafalgar Square, he found soot and dirt collected on the *underside* of the cornice projections to the thickness of three-quarters of an inch or more.

The architect of the London County Council found that in repairing the York Water Gate in the Victoria Embankment Gardens over a surface of about 354 superficial yards of Portland stone, about two hundredweights of loose dirt and sooty deposit were removed by brushing with bristle brushes ; and that after this there still remained over the whole of the surfaces which had not been subjected to driving rains a bituminous deposit, and on the underside of the projecting features a kind of stalactite mingled with bituminous deposits.

From these two examples it will be evident that the soot deposited on the architectural features must in time cause a considerable alteration of their original forms, filling up recesses and marring the purity of the outlines.

(6) A much greater evil, however, is that of erosion arising from the by-products of coal combustion. From the moment that any limestone—and the majority of building stones used are limestones—is exposed to the influence of smoke-polluted atmospheres it begins to deterioriate. Lime has a great affinity for sulphur, and smoky air contains a large quantity of this element. The absorption of the sulphur by the limestones causes an increase of bulk in the particles, and the stone is converted from a hard, solid substance insoluble to water to a powdery substance easily soluble in water. In consequence, little by little the body of the stone is washed away by the rains and blown away by the winds, so that in time its original form is quite lost.

It is clear that the architect who considers the future appearance of his stone buildings must take into consideration these two factors of soot deposit and erosion ; and that unless he makes up his mind to forego all effects which may be attained by undercutting, delicacy of incised line, and sharpness of angular forms, his building will very soon lose its original force of expression and will degenerate into a mere mass of dirty and shabby masonry. There is no need for me to instance any particular buildings to exemplify this—one has only to walk through the streets of London and to use one's eyes.

It is in stone that the troubles are chiefly in evidence. But woodwork is by no means exempt from obliteration of detail ; and metal-work, particularly unpainted metal-work, such as bronze, is much affected, both by soot, tarnish, and erosion ; and in this regard the appearance of our public statues and monuments will speak for me.

I submit, then, that by this curse of coal smoke the architect—and, of course, the sculptor—suffers the most grievous restrictions

in the exercise of his art; for not only is he subjected to the malign influence of the smoke on his materials, but by the smoke pall he is robbed of light of the quality required for the definition of form. My meaning will be clear to anyone who has walked through London on a Monday after daybreak in summer.

(7) I would now invite your attention to what the architect is doing to mitigate the evils which arise from coal smoke.

First as to stone. The method which at present is chiefly in use for the treatment of limestones affected by smoky atmospheres is the Baryta treatment, first advocated by Sir Arthur Church, and it is this method which is advocated by the Society for the Protection of Ancient Buildings, and which has lately been used by the Architect of the London County Council, in consultation with the Chief Chemist of that body. The Society for the Protection of Ancient Buildings, however, advocates also the use of repeated coats of thin limewash made by slaking lias lime with boiling water, following the old custom. Mr. Thackeray Turner informs me that about fourteen years ago, when repairing Hatfield Church tower, he coated the decaying stone with as much slaked lime in a thin liquid state as the stone would absorb; and that so far the stone has shown no sign of further decay, although at the time when the repair was done it was confidently expected that further treatment would be required in the course of six or eight years.

The tower of West Ham Church was also treated by the limewash method some years ago.

The Society strongly advocates, even when baryta is used, finishing with one or two coats of limewash, particularly for porous stones, and in cases where the use of bartya has resulted in an unpleasant colour. This unpleasant colour is clearly exemplified in the treatment of the walls of the Chapter House of Westminster Abbey, carried out some years ago by Professor Lethaby, where there is no finishing coat of lime. Here there are already signs of decay beginning again upon the wall arcading.

In this connection it is very interesting to learn the experience met with by the architect of the London County Council when dealing with the old York Water Gate, to which reference has already been made. The work was undertaken a year ago, a favourable time on account of its being such a dry summer. The building is of Portland stone, which was extensively decayed. It will be remembered that when the soot and loose matter had been removed by brushing, there remained bituminous deposits. These were found to be impenetrable by the baryta-water; and the difficulty which arose was their removal without injury to the stone, much of which was in a very friable condition. Washing with water had no effect, with soda and water little or none, and eventually recourse was had to watering

the deposits with a solution of caustic soda and spraying them with a jet of steam. This method effected the removal of the deposits, but in obstinate cases two, or even three, applications of soda and the steam jet were necessary; and the soda had to be dabbed on and left for some hours before the steam was used. By this treatment the whole of the stone was cleaned, and the surface exposed for the absorption of the baryta-water. After all loose pointing had been removed and the joints cleaned, the baryta-water was applied in a saturated solution by painters' brushes, coat upon coat, until the stone would take up no more. In many places thirty coats were necessary, and in none was less than a dozen given, the average number being about eighteen. The joints were carefully repointed with mortar composed of one part of lias lime and five parts of coarse washed sand; and missing drip stones, essential to throw off the rain and surface defects, were made out roughly to the original forms in similar mortar and pieces of hand-made tile, dowelled into the sound stonework without any attempt to "restore" the decorative features.

About four weeks after the completion of the work an analysis of the stone made by the Council's chief chemist disclosed that the baryta had entered into combination with the stone for a depth of at least three-eighths of an inch from the surface, having the effect of converting the decayed stone into a weather-resisting substance.

A most interesting point about this work is that the treatment by baryta-water has produced no discolouration of the stone such as has been noted elsewhere, where the effect is as if the stone had had a coat of Portland cement, and this result seems to suggest that the unpleasant colour may be due to the admixture of surface dirt with the baryta-water, as in the case of the York Water Gate the dirt was all thoroughly removed before the treatment.

(8) Building stones other than limestones are not so much affected chemically as mechanically by the soot, which encourages the absorption of rain water into the joints and holds it under projecting features, with the result that frost causes damage. To these stones the baryta-water treatment is not applicable, and waterproofing must be resorted to. There are many compositions of this nature on the market. Most of them are compounded of silicate of soda or heavy oils. Sodium silicate is soluble in soft water, and oils evaporate in time. So that neither is permanent. The old-time method of a coat of soft soap followed by a coat of alum dissolved in water is efficacious. Another, and perhaps the most modern, method is a solution of ceresin wax in petroleum solvent applied whilst the stone is dry and warm.

(9) *Statuary* is sadly affected by smoke. All that can be done is to keep it clean by washing and protect by a thin layer of

some waterproofing solution, such as the ceresin wax with perhaps a little copal added to prevent stickiness. But in these cases surface textures have to be carefully considered. The Boadicea group and other monuments on the Thames Embankment were recently successfully cleaned under the direction of the County Council's architect by a steam jet, with the result that after the removal of the bituminous deposits a pleasant green patina was exposed to view.

In conclusion, I would particularly invite your attention to the obstacle presented to an appearance of cleanliness by the presence of the bituminous deposits to which reference has been made. We have seen that this dirt cannot be removed by washing, and that recourse has to be had to heat or scraping. The effect of the deposit is plainly apparent in the cases where white glazed brick surfaces or painted buildings have been washed down.

So that so long as coal smoke continues, even building in glazed brick or faience, as has been tried, cannot in the long run retain its purity of colour.

Effects of Town Air on Metal Work.

By Dr. S. Rideal, D.Sc., F.I.C.

Everyone has noticed the more prominent of these effects in the occurrence of tarnishing and disfigurement, but a third more deep-seated one, often of greater importance, namely corrosion, frequently escapes observation. The phenomena are partly mechanical and partly chemical, and their causes may be classified as follows, noting that they will in a large number of cases act conjointly. The order is taken in time-sequence, as they usually come into operation.

(1) Direct action on the metallic surface of certain gaseous impurities in the air.

(2) Deposit of a carbon layer from the soot.

(3) A greasy coating from hydrocarbons which attracts dust.

(4) A corrosive film from acid vapours.

The second and third, or mechanical causes, greatly obscure and disfigure a bright metallic surface, but do not of themselves corrode it ; in fact, a hydrocarbon layer would, as is well known, actually form a protection, if it were uniform. But, unfortunately, it is not, and only gathers in drops and smears, and the metal becomes in consequence mottled and unevenly affected. Simple soot due to almost pure carbon is easily detachable, and it is only when the brown adhesive hydrocarbon soot is present that it is more difficult to clean. On the other hand, the deposition of the combined carbonaceous coating involves an immense amount of labour in removal, the tarry matters derived from the imperfect combustion of coal being the main difficulty. The remedy for the evil is obviously the prevention of smoke by a complete and economic combustion in grates and furnaces. This will be reverted to later.

In reference to the first cause given, the direct action on metallic surfaces of gaseous impurities, there are districts in manufacturing towns (including London) where hydrochloric acid, spray or dust of various chemicals, ammonia of sulphuretted hydrogen are emitted from the works. But away from these the last-named gas is continually occurring in towns, derived from the incomplete combustion of coal in domestic grates : sewers. and putrefaction, emanations from human beings, or accidental leakage of unpurified coal gas, accounting for smaller quantities. It is hardly necessary to mention the tarnishing and blackening effect on nearly all metals.

Sulphuretted hydrogen requires special attention as the only ordinary gas which attacks silver, and apart from the expense of continually cleaning with whitening or other polishing agent, there is a constant loss of the precious metal in the removal of the film of silver sulphide ; a loss that might be calculated

from the gradual thinning and reduction of weight of silver articles in time, and would amount to a very serious aggregate. In silversmiths' shops it is avoided, at another expense, by encasing the window, but, when taken out and exposed to town air, the articles rapidly tarnish.

Aluminium is unaffected by sulphuretted hydrogen itself, but, on the other hand, is susceptible to chloride vapours, to many acids, and to alkalies which may be used for cleaning. In spite of its valuable qualities for domestic application it is not invulnerable against town air.

Copper and brass are particularly sensitive to attack by sulphuretted hydrogen. A familiar example is the rapid darkening of copper or bronze coinage, the coating being mainly sulphide. Although the cause may be mainly due to human exhalations, there is no doubt that copper or brass surfaces remain bright longer in the country than in towns, and this has a special interest to tradesmen on account of the collectively immense area of brass exposed on shop name-plates, which require with constant labour to be kept immaculate.

Ammonia, also present in small quantity in the air of towns, can also attack copper or brass, and with the aid of atmospheric acids can form the green or blue incrustations which are commonly called "verdigris."

These actions are intensified, generally or locally, if the active impurities are condensed by soot, or brought down by rain; and not simply tarnishing of the surface, but actual corrosion of the body of the metal, may be occasioned. Some analyses of London soot collected from glass roofs in dry weather gave in percentage averages :—Carbon, 39 to 43; hydrocarbons, 5 to 14; sulphuric acid, 4; hydrochloric acid and ammonia, each about 1; the rest being mineral matter containing oxide of iron, with some moisture. There is not sufficient ammonia to neutralise the sulphuric and hydrochloric radicles, therefore such soot is acid in reaction. Samples of soot in Glasgow have contained as much at 7·9 per cent. of SO_3. In the elaborate and valuable research under the auspices of the Coal Smoke Abatement Society, reported in the *Lancet* of January 6, 1912, under the title of "The Sootfall of London," observations are published for the year from June, 1910, to June, 1911, made at three stations in London, and one on the borders of the metropolitan area at Sutton, Surrey. They show that the deposit is greater in the City area, amounting to about 650 tons per square mile, that in the south-western district it was 460 tons, and at Sutton 195 tons, the maximum fall being generally in the late autumn, the period of fogs. In the S.W. district the insoluble deposit, mainly soot, was less on the whole than that which fell in the City, and in the suburban area typified by Sutton it was only about one-sixth of that in the metropolis. The soluble matters deposited included ammonium and calcium salts, sulphates and chlorides,

and some organic constituents, among which acetic acid was certain to have occurred; the quantity of soluble matter in the suburban district was again less. Particular attention is drawn to the sulphate figures, "inasmuch as most, if not all of the sulphur found in rain may be traced to the combustion of coal or gas." The City area receives nearly double as much sulphate as the S.W. district, while in the suburban area there was often only a trace, and sometimes none. Ammonia is a product of the faulty combustion of coal: coal gas is free from ammonia and yields none on burning. The amount in the S.W. district is three-fourths, and that at Sutton one-twentieth, of that in the City. It is stated that rain in the metropolis is rarely acid in spite of its load of impurities, while in Leeds, Glasgow, and Manchester acidity is constantly reported. This is attributed to the comparatively less development of factories in London as a whole, and also to the fact that domestic fires tend to make the smoke alkaline from ammoniacal tarry compounds.

Davis calculated that "coal smoke alone produces annually in the British Isles about 3,000,000 tons of sulphuric acid, most of which is showered down in the rain," and Dr. Carpenter estimated that at Widnes the same source gave 120 tons of sulphuric acid per day, to be condensed on metallic and other surfaces. Angus Smith found that the sulphuric acid in town rain was from 6 to 26 times that in the country, the average in English towns being about 13. The *Lancet's* analyses of London and Kent snow in 1906 showed in the former (as grains per gallon) 1·73 of sulphuric acid and 5·6 of solid matters containing tar; in the latter the figures were nil, and 1·68 respectively. The Manchester Air Analysis Committee at an earlier date published a large number of determinations of the oxidised sulphur in the air of their city. Some of my own results with the atmosphere of towns as compared with the country have been recorded in the Journal of the Sanitary Institute and elsewhere.

I may recall an interesting observation of G. Witz in 1885 (*Comptes Rendus*, c. 1385) from which he inferred the existence of sulphurous acid "as a normal constituent of the air of towns." He remarked that placards covered with red lead, posted in situations where they are protected from the sun and rain, become gradually decolourised, whereas similar placards exposed under similar conditions in country air retain their colour unimpaired. The decolourised placards were found to contain lead sulphate and lead sulphite. He was also frequently able to recognise sulphurous acid in hail, snow, and especially hoarfrosts in the neighbourhood of towns.

But although the sulphur impurity of town air is commonly spoken of as sulphurous acid, the statement is not generally correct. As diffused in contact with excess of oxygen and moisture, aided by traces of nitrous compounds, and by ozone, which by this and other processes is eliminated from town air,

SO_2 is almost at once oxidised into the more energetic sulphuric acid, and by this oxidation the destructive activity on metals is increased.

Some other ingredients of soot that would seem at first sight to be inert, namely carbon and oxide of iron, have been proved to be agents in corrosion, on account of the fact that the action is probably for the most part electrolytic. Sir Gerald Muntz at the Institute of Metals in 1910 attributed a great part of the corrosion of brass in sea water to "the juxtaposition of carbon." Tilden found that ferric oxide in contact with iron formed a couple in which the oxide was electro-negative, therefore the oxygen would be driven towards the metal, accounting for the gradual invasion of "pitting" under the spots of rust. Moreover, oxide, like all porous substances, absorbs air, and in that way tends to localise the effect. Bruhl's researches for the same Institute in 1911 also led to a conclusion that the local effect known as "pitting" was caused by electro-chemical action set up by certain substances, "and of these ferric hydrate and carbon are probably the worst."

Even when we protect bright surfaces in towns by gilding we find that its brightness does not last, and gold articles often become dull. The pure metal gold is little affected by atmospheric influences, but on account of its softness it is alloyed with copper and sometimes other metals to such an extent that some of these mixtures are nominated as "9 carat," or only 37 per cent. gold. The alloys will be, of course, affected proportionately by atmospheric tarnishing, and their frequent cleaning will occasion an appreciable loss of gold. Modern electro-chemistry has succeeded in plating with alloys. Much gold leaf is hammered from an alloy, and it has been remarked that the gilt titles of books in town libraries have a tendency to become faded which does not occur in the country. It is evident that with all bright metals the constant cleaning necessitated by the attack of town gases, and the sooty film, occasions a loss of the body of the substance, without speaking of the immense aggregate labour involved. Brass and bronze are not dissolved uniformly, the more positive metal zinc being oxidised first, so that in extreme cases the copper is left in a spongy state, the alloy becomes brittle and is rapidly worn away.

Atmospheric corrosion effects constant damage, resulting sometimes in serious accidents, by causing loosening or detachment of metallic fastenings. The perishing of wires and electric fittings has given rise to interrupted connections or even to fires from short circuits.

The corrosion of iron is deeper and more rapid. In a pure atmosphere, containing besides the inert nitrogen only oxygen, carbon dioxide and water vapour, iron can remain nearly or quite rustless. The ordinary commercial metal has less immunity, since it contains, among other impurities, sulphide, phosphide,

carbide and free carbon ; still the action under these conditions is slow. But if saline substances and strong acids are introduced with the water, the rusting become active, and with the aid of electrolysis the corrosion quickly extends. It may be noticed that with nearly all metals, whether the vapours or solutions are acid, alkaline, or neutral, if salts are present the latter become dissociated by great dilution, and the ammonia can act, for instance, on copper, and the sulphuric acid on iron.

I was called in consultation in 1905 on the accident at the Charing Cross Station, when the roof girders collapsed through rusting, and analysed many samples of the rust. One sample from a lateral girder contained 4·25 per cent. sulphuric acid (as SO^3), equal to 8·95 per cent. of iron dissolved as ferrous sulphate. The rusting is obviously more rapid in closed spaces where the acids from coal consumption are restricted in range, and especially on a roof where condensation will occur. At the same time similar results of analysis were obtained from other London stations, while in the open country and at an erection in a small town (Dorchester Cattle Market) exposed iron had much less rust, with about one-fourth to one-third the amount of sulphate. It was found in this case that the accident was owing to the structure not having been properly protected by painting. When hot oil is put on the clean metal immediately after rolling, it forms a permanent coating; similarly in repainting old work it is essential that it should be properly cleaned with wire brushes and freed from rust and a coating of oil applied hot, which will then adhere.

Other constituents of town soot deposits are chlorides and lime compounds. The above-mentioned report on the sootfall of London remarks that " the presence of chlorides in the rainfall of London is a mystery, as both coal and gas are free from chlorides." But the distinct traces of chloride in various coals have escaped notice as not being ordinarily of commercial importance. Wills found in one variety from Staffordshire 0·06 per cent. of chlorine. There are also several other sources of chlorides in the atmosphere of towns, such as the burning of refuse, and an appreciable amount is given off by living beings. It has been proved that marine spray is often carried by wind for long distances inland, and this in towns is absorbed and concentrated by the soot. Sulphuric acid from coal burning would liberate hydrochloric acid from chlorides, and the latter acid has a quicker solvent action on many metals than sulphuric. As to lime compounds derived from the ash of coal and from the dust of building operations, they simply, as a rule, add mechanically to the incrustation on metallic surfaces, and may rather hinder corrosion.

A few words must be said on the action of some of these impurities on metallic pigments. Unfortunately, many artists, notably Turner, have made free use in their pictures of lead preparations, which are seriously affected by sulphuretted

hydrogen and sulphurous acid, the one by blackening, the other by bleaching. The best varnishing, and even glass, does not protect entirely from town air. Darkening of ordinary white paint, containing as it does lead hydro-carbonate, is familiar, and necessitates continual great cost in repainting.

As to remedies for the action of town air on metals, protection of the surface has always been practised, and varnishing, lacquering and painting are effectual for the time. The principle of guarding by a more electro-positive metal, as in the so-called galvanising with a coat of zinc, is one of the resources ; in this case atmospheric action causes a solution of the zinc, or a crust of oxide, carbonate, or basic sulphate, while the structural iron is protected. On the other hand, in common tinning, although tin itself is almost proof against air gases, the iron underneath, if in any way the coating be broken, is more rapidly corroded. Plating with nickel is well known. Aluminium is especially affected by alkalies ; a recent patent (22,684 of 1910) protects it by a film of copper, supplemented by a special lacquer. I found that the coating retards the attack on the metal and prolongs its life for many industrial purposes.

Some of the more or less successful protective methods depend on forming hard uniform and coherent coatings analogous to those which are produced irregularly and loosely by atmospheric influences. Examples are the Bower-Barff process, in which a film of magnetic oxide is formed on iron by heating in steam ; the "bronzing" or "browning" of gun-barrels, and the sulphurising or so-called "oxidising" of silver.

In America a very pure form of iron called "ingot iron" has been recently made, and is said to be almost rust-proof and to have a power of resisting acids which is twenty times that of ordinary steel.

A common drawback of coatings of metals less subject to attack, and of varnishes and lacquers, is that they either crack or scale off easily or have pin-holes or scratches ; such defects in many cases increase the rate of corrosion, making it irregular and local, and actually more dangerous because unseen. Enamelled iron is good when stationary, and it is common observation how serviceable it has proved for street signs.

I dealt with this subject at the Conference on Smoke Abatement in 1905, and gave statistics of the time in the paper "Acids of Smoke," published in the Journal of the Royal Sanitary Institute. Since then there has been much improvement in the conditions, owing to the work of Smoke Abatement Societies, and to the introduction of smokeless lighting by incandescent burners and by electricity, and of heating by gas stoves instead of coal fires. We must remember in the present purification of gas, 90 per cent. of the sulphur in the coal is removed, and the methods of burning eliminate the evils of smoke and soot, which we have shown to have pre-eminently the most injurious effect on metals.

Smoke and Fog.

By the Hon. Rollo Russell, M.A., F.R.Met.S.

The last ten years have been remarkably free from dense fogs, not only in London but in the south of England generally. Meteorological conditions have been such that occasions for the development of dense ground fogs have been unusually few. This is not a mere impression, but is derived from an examination of the Greenwich, Kew, Oxford, and other records. So rare have been the days and nights of calm, great cold, and dense fog, that we cannot know how the worst kind of London fog of the present would compare with one of thirty years ago. There can, I think, be little doubt that it would be somewhat less intense or less dark. It was not a very uncommon thing in the early eighties to be unable to see across a street. But no such condition as a night temperature of 15 to 20 degrees, with dense ground fog, and persistent active terrestrial radiation under a clear sky, has happened for a long time past. The test comes when a low or ground fog forms over London during the night with a very low ground temperature in radiation weather, and when air currents are so slight and various that the slow mixture of horizontal streams maintains the precipitation of moisture and prevents the sun's heat from effectively dissipating the fog, especially where mixed with smoke. It may be that when such a conjunction occurs, very dense and dark fogs may still take place in London. But there are reasons for expecting that they will not occur so frequently, and that they will not be quite so bad as in former times. The great extension of the area of streets and houses to hills, valleys, and level pasture lands around the capital must largely reduce the area over which radiation causes temperature to fall to extremely low points in clear, calm weather, and the air over houses must modify the cold air lying over grass fields, which moves in the direction of the central districts. In former times the air over the grass of the parks was colder than the air of the streets, and I have seen cold streams of fog pouring down Grosvenor Place from Hyde Park, adding much to the density of the fog in the thickly-populated area to the south. It is not now possible for the dense natural fog of the grassy land round London to reach the city without much modification and some elevation of temperature. The many square miles of streets and houses, I think they are over 100, add very considerably to the temperature of the air near the ground ; consequently if it were not that much smoke is emitted in the morning hours, especially about 7 to 8 and 9. ordinary

natural fogs would be much diminished over the London area. But where the layer of vapour and precipitated moisture is reinforced by smoky particles, especially if they are black or brown and of tarry composition, the radiation from the carbonaceous matter and water particles combined causes further deposition of moisture, the oblique sun's rays are intercepted, and vertical radiation continues to the clear sky, maintaining the layer unevaporated sometimes during a whole day. It seems likely that the worst fogs will require a lower temperature than formerly owing to the increased inhabited area, and owing to the very much larger emission of warm air over the town.

Another influence tending to reduce the worst fogs is the increased use of gas. However many millions of dust particles may be emitted from gas burners and gas fires or from wood fires, these particles have no effect in increasing fog, as was proved by the clear air of Paris, Pittsburg, and other non-smoke-producing cities.

Further, there are improved grates and kitcheners, and some extension of radiators and central heating, which reduces the smoke product per head.

The efforts of the Coal Smoke Abatement Society have brought about an improvement in stoking, which is one of the most important of all factors, and a reduction in the emission of black smoke. There is still a deplorably large quantity of black and brown smoke emitted between 7 and 9 a.m., and before the evening dinner time in West London, especially from clubs and hotels. If it were practicable to revive the old law against the burning of slack and smoky coal without apparatus for smoke consumption, the result would be a large economical gain to the community.

The worst offence certainly comes from domestic fires, for the darkest fogs have been on Sundays and Christmas Day. The climate of London is far from bad; in fact it is one of the best in England, but it is spoilt by coal smoke and by coal smoke alone.

It is worth while to set on foot an inquiry to ascertain, as nearly as the difficulties of the subject admit, the total cost of the damaging matter, the waste fuel and refuse, thrown into the atmosphere, and to devise means for the emancipation of London from the oppression of its self-blotted skies.

Sunshine Records.

A Comparison of Sunshine Statistics for Urban and Rural Stations.

By R. G. K. Lempfert, M.A.

(Superintendent Forecast Division of the Meteorological Office).

The diminution of fog in London in recent years is not merely a general impression, but a fact which is confirmed by official figures. In 1905 Mr. F. J. Brodie read before the Royal Meteorological Society a paper* in which he discussed the observations of fog occurrence made at Brixton, the London station of the Meteorological Office, for which information was published in the Daily Weather Report up to the end of 1904.

The observations were taken throughout the period, which commenced in 1871, by the same observer, and it may therefore be assumed that the standard of what was to be counted as a "day of fog" did not vary. The station at Brixton was discontinued in 1906, and in trying to bring Mr. Brodie's figures up to date we are met by difficulties due, firstly, to change of site, and, secondly, to change of observer. It is notoriously difficult to get different observers to agree as to the amount of obscuration of the atmosphere which must be attained before a day can be classed as one of fog. It must, therefore, be borne in mind that any figures which we can give for more recent years are not strictly comparable with these for Brixton for the period 1872-1903. I have appended to this paper two short tables showing for the London stations for which meteorological statistics are available the number of days of fog (1) for each calendar year since 1904, and (2) for each winter half-year since that date. The figures show a steady decrease for most stations, which is particularly marked during the last two years. The observations taken at the Royal Observatory, Greenwich, show the least conspicuous decrease. Those for West Norwood are comparable with those for that place contributed by Mr. W. Marriott and printed in the Quarterly Journal of the Royal Meteorological Society, in the report of the discussion of Mr. Brodie's paper.

It is my object in this paper to examine the statistics of bright sunshine for London and other large towns to see whether they afford evidence of progressive amelioration or the reverse of the smoke nuisance. The average loss of bright sunshine which London suffers was assessed in a table included in the report

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* Q. J. R. Met. Soc., Vol. XXXI., 1905.

on the London Fog Inquiry* of 1902-3. By comparing the 20 year averages of the monthly duration of bright sunshine for stations in London with corresponding values for stations in more rural situations, the following percentage losses were determined for Westminster and London City (Bunhill Row) :—

PERCENTAGE LOSS OF SUNSHINE IN LONDON.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
City . . .	71	58	43	25	12	12	14	16	25	40	62	83	38
Westminster .	62	55	45	30	18	19	17	14	22	35	51	61	36

In what follows I have expressed the sunshine recorded at the town stations as a percentage of that recorded at country stations for each year separately. I have not been able to deal with all twelve months and have therefore confined myself to two seasons of two months each, winter consisting of December of one year with January of the next, and summer consisting of June and July. The sunshine records of the Meteorological Office commenced at the end of the seventies, but there are few stations for which complete records extend as far back as 1881, which I have taken for the commencement of this investigation. I have, therefore, had to compare stations at which the meteorological conditions may be decidedly different, so that we cannot attribute the differences in the duration of bright sunshine entirely to the effect of smoke. Nevertheless, it seems not unreasonable to attribute regular and progressive changes in the ratio of town sunshine to country sunshine to this cause. The ratio naturally varied greatly from year to year, but if the results are grouped together to give means for successive periods of five years the variations assume a more regular aspect.

The result for the London stations are given in Table I. In the first set of figures the mean of the amounts of two stations, Westminster and City (Bunhill Row), both well within the boundary of Inner London, are expressed as percentages of the means of four "country" stations, Oxford, Cambridge, Marlborough and Geldeston. The great difference between the figures for winter and those for summer suggests that domestic smoke rather than factory smoke is mainly responsible for the loss of sunshine. The winter figures show a slow but definite improvement, from 17 per cent. in the lustrum 1881-85, to 38 per cent. in that beginning with 1906. In summer the improvement has been less conspicuous, but the amount of sunshine has increased by about 10 per cent. since the decade 1881-1890. The next sets of figures give the comparison of the results for Kew Observatory, firstly, with the same combination of country stations, and secondly, with the metropolitan stations. In summer Kew suffers no loss: the figures show that the average duration of sunshine exceeds that at the country stations selected for comparison. In winter there is appreciable loss of

* Meteorological Office Publication, Official No. 160.

sunshine, and its amount appears to have been increasing slowly since the lustrum 1896-1900, probably a result of the westward extension of streets of dwelling houses.

TABLE I.

DURATION OF SUNSHINE AT "TOWN" STATIONS EXPRESSED AS A PERCENTAGE OF THE DURATION AT "COUNTRY" STATIONS.

	City and Westminster. / Oxford, Cambridge, Marlboro', Geldeston		Kew. / Oxford, Cambridge, Marlboro', Geldeston.		City and Westminster. / Kew.	
	Winter. %	Summer. %	Winter. %	Summer. %	Winter. %	Summer. %
1881–1885 . .	17	83	85	97	20	84
1886–1890 . .	29	85	89	96	32	87
1891–1895 . .	32	95	83	102	39	94
1896–1900 . .	35	89	97	103	36	86
1901–1905 . .	32	93	88	104	37	89
1906–1910 . .	38	92	81	99	46	92
1911 . .	29	97	69	102	41	94

The figures represent the sunshine at the station or stations above the line expressed as a percentage of that at stations below the line.

Winter = December + January. Summer = June + July.

Table II. gives corresponding results for some large provincial cities. At Birmingham the sunshine is recorded in the residential suburb of Edgbaston, about a mile to the south-west of

TABLE II.

DURATION OF BRIGHT SUNSHINE IN LARGE MANUFACTURING CENTRES EXPRESSED AS A PERCENTAGE OF THE DURATION IN NEIGHBOURING COUNTY STATIONS.

Lustrum.	Birmingham / Oxford.		Glasgow. / Stonyhurst.		Manchester. / Stonyhurst.		Manchester. / Hodsock.		Newcastle. / Durham		Hull. / Scarborough.		York. / Oswaldkirk§ or Harrogate.	
	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.
1881–1885 . . .	—	—	64	81	—	—	—	—	—	—	—	—	—	—
1886–1890 . . .	82*	75*	63	90	—	—	—	—	—	—	—	—	73	104
1891–1895 . . .	71	71	72	89	64†	81†	65†	100†	66†	—	—	—	75	111
1896–1900 . . .	73	72	79	73	62	90	57	101	57	85	—	—	76	107
1901–1905 . . .	60	80	51	84	62	91	53	101	58	84	24‡	75‡	57	94
1906–1910 . . .	59	82	57	94	63	92	52	101	47	83	43	84	70	92
1911. . .	57	78	79	84	—	—	—	—	42	83	45	84	69	96

* Four years, 1887–90, only. † Two years, 1894 and 1895, only.
‡ Three years, 1903, 1904, 1905, only.
§ Oswaldkirk, 1886–1899; 1900 and 1901 missing. Harrogate from 1902.
The Birmingham record is taken in the suburb of Edgbaston.
The Manchester record is taken in the suburb of Prestwich.

the centre of the town. The meteorological station is at the waterworks, at the highest part of the town, 535 feet above sea level, and 100 feet above the general level of the central part of Birmingham. The comparison is made with Oxford. The figures given in our table are reminiscent of Kew rather than of Westminster or Bunhill Row, and it is probable that a recorder placed in the centre of the town would show a much greater loss of sunshine. The Edgbaston record shows a much smaller difference between winter and summer than is the case at Kew, which may mean that at Birmingham factory smoke, which is emitted all the year round to approximately the same extent, forms a much larger proportion of the whole smoke. The winter figures show a steady decrease from 1887 onwards, while those for the summer show a slow but decided improvement. The winter decrease is probably due to the increase of domestic smoke in the Edgbaston district, while for the summer increase more careful management of factory furnaces suggests an explanation.

At Glasgow the Observatory is also not in the centre of the town. It is situated on Dowan Hill, well above the general level of the town, about two miles to the north-west of its centre, and also in a suburb which is mainly residential. The comparison is made with Stonyhurst. The lustrum 1896-1900 shows a maximum of winter sunshine and a minimum of summer sunshine, which suggests that we have here also an indication of an increase of winter smoke of domestic origin due to building houses in the neighbourhood of the observatory, coupled with more effective methods of dealing with factory smoke.

For Manchester we have a record extending over twenty years for the suburb of Prestwich, on the north side of the town, four miles distant from its centre, and 320 ft. above sea level, well above the general level of the town. The comparisons with Stonyhurst and Hodsock Priory, near Worksop, show that conditions at Prestwich have remained approximately unchanged during the past 20 years. In Table III. I have given some figures for the stations at Manchester city and Whitworth Park, the latter about two miles from the centre of the town and on its south side. The figures for the centre of the city resemble those for Westminster and Bunhill Row in the great contrasts between winter and summer. The decided increase in the winter sunshine in the city during the last few years is hopeful.

A comparison of Newcastle with Durham shows a progressive decrease in the amount of winter sunshine at Newcastle as compared with Durham. The figures for the summer show practically no fluctuations.

For Hull we have a short series commencing with 1903. The recorder is at the Pearson Park, and the site may be described as urban rather than suburban, though the immediate neigh-

bourhood is residential. Compared with Scarborough, the figures show a distinct increase in the amount of sunshine, both for summer and winter, during the later years. We should like

TABLE III.

THE SAME FOR MANCHESTER AND HULL.

	Manchester (City). / Hodsock (Worksop)		Manchester (City). / Prestwich.		Manchester (Whitworth Pk.). / Prestwich.		Hull. / Scarborough.	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
1903 . . .	—	—	—	—	—	—	15	72
1904 . . .	—	—	—	—	40	85	33	75
1905 . . .	—	—	—	—	124	92	13	78
1906 . . .	28	84	43	85	52	91	41	84
1907 . . .	15	80	32	81	94	85	32	68
1908 . . .	37	91	58	83	97	86	26	92
1909 . .	24	99	57	99	84	90	60	74
1910 . . .	40	89	93	93	112	96	58	100
1911 . . .	41	70	—	73	—	96	45	84

to think that this improvement is due to a decrease of smoke. This may be so, but there is another possible explanation, viz., that in 1903 the recorder was removed to the top of a specially constructed wooden tower, whereby its exposure was considerably improved.

All the sunshine records which have been discussed in this paper have been obtained with instruments of the Campbell-Stokes type. The increase in the relative amount of sunshine at town stations, which is particularly conspicuous in the case

TABLE IV.

NUMBER OF DAYS OF FOG AT LONDON STATIONS—CALENDAR YEARS.

	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.
Greenwich . . .	64	44	33	65	52	50	48	31
Kew	107	75	61	83	31	32	14	24
Tottenham . .	—	—	—	22	26	18	16	9
Camden Square .	—	49	25	34	22	15	7	11
Westminster . .	30	23	23	37	15	12	4	—
Norwood . . .	104	72	72	98	77	57	41	34

of the London stations in winter, might conceivably be due to a progressive change in the instruments used whereby they have become more sensitive to faint sunshine, for it is well known that the intensity as well as the duration of bright sunshine is much diminished in towns. We have, therefore, to consider this possibility before we accept the figures I have quoted as definite evidence of smoke abatement. The cards have in all cases been sent to the Meteorological Office for examination, and for the purpose of having the tabulations checked. Systematic differences in the method of tabulating have thus been, as far as possible, avoided. The instruments have been of the same type throughout, in most cases the same instrument has been

in use throughout. It is found that the glass spheres used with the recorders, which are colourless when new, become yellow in colour after they have been in use a few years. Experiments have shown that the burning power of the lens is not affected by this change ; moreover, we should naturally expect it to work in the direction of decreasing rather than of increasing the sensitiveness to faint sunshine. There remains the question of a possible change in the sensitiveness of the card. The standard for composition and colour of the cards was originally agreed on as the result of experiments by Sir George Stokes

TABLE V.

Number of Days of Fog at London Stations.

Winter Season (October-March inclusive).

	1904/5	1905/6	1906/7	1907/8	1908/9	1909/10	1910/11	1911/12*
Greenwich . . .	53	39	44	48	44	47	41	26
Kew	72	49	65	47	25	17	18	27
Tottenham . .	—	—	—	31	17	10	17	5
Camden Square .	—	39	33	24	20	5	12	9
Westminster . .	28	18	21	26	11	7	—	—
Norwood . . .	79	50	61	65	65	35	36	—

* 5 months only.

and Mr. Warren de la Rue. The cards have been supplied throughout by the same firm. In 1907 it was noticed that the cards then in use were rather more combustible in strong sunshine than those originally used had been. Representation were thereupon made to the makers, and steps were taken to return to the original standard. It is noteworthy that after this date the ratio of town sunshine to country sunshine shows no tendency to return to the low values which characterised the earlier years of our records. Fortunately the cards for all the stations have been preserved, and the material is thus available for an investigation of a possible change in the sensitiveness to faint sunshine.

A Note on Recent Observations of the Smoke Nuisance at Kew Gardens.

By W. J. Bean
(Assistant Curator, Royal Botanic Gardens, Kew).

The amenities of the north-west part of the Gardens have been considerably improved since action was taken with regard to the factory chimneys of Brentford. The clouds of smoke that used to make that part of Kew positively unpleasant to sight and smell whenever the wind came from the direction of Brentford are now very seldom seen. Steam tugs are the worst offenders now. With regard to plant life, it had become impossible to grow certain evergreens, especially conifers, on that side of the Gardens. Newly planted trees never throve, and those that had been established many years eventually got into such miserable health that they were nearly all dug out. But evergreens planted in recent years have succeeded much better. The best evidence, however, of the improvement of conditions for plant life in this part of the Gardens is provided by an old Cedar of Lebanon. It is one of the largest in Kew, and has improved perceptibly in health during recent years. As other conditions remain precisely as they were, we ascribe its better appearance to the improvement in the atmosphere. Considering how precious these fine old cedars are, and how sadly their numbers have been decreasing for years in the suburbs of London, more through the evil effects of smoke than all other influences put together, the improvement in this particular case is very gratifying.

There is nothing so disheartening to the cultivator at Kew as the deleterious influence of smoke. Whilst the peculiarly virulent effects of locally produced smoke have been ameliorated, the general atmosphere, especially when the wind is from the east, is still very bad. A clean white fog is advantageous rather than otherwise to evergreens, but a typical London fog is murderous. Money and skill can remove most natural disabilities and disadvantages for gardening, but are powerless against London smoke. If that were removed plants could be made to succeed as well in the larger London parks and gardens as in country places. As it is, one can only contemplate the future of Kew with misgivings.

The Effect of Smoke on Vegetation.

By Miss M. Agar
(Landscape Gardener to the Metropolitan Public Gardens Association).

The necessaries to plant life are water, nutrient salts and gases, light and heat.

The water supply in towns is no difficulty, or if it is, smoke is not the cause of shortage. Of course, when the water is impure, the nutrient salt supply is affected. Town soil is not naturally deficient in food salts, it is the extra substances that destroy the soil's fertility. The acidity of town soil from the washings of sulphuric acid is a check to root action, and it is probable that the germ life, to which soil owes its fertility, is also checked.

Nutrient gases, of which carbonic acid is the chief, are abundantly present in towns, more so than a plant of the most vigorous type could absorb under the best circumstances. But, as light is necessary for a plant to make use of carbonic acid gas, the abundant supply is no advantage. There are, moreover, constituents in a town atmosphere which are deleterious to vegetation. Of these, the gas that becomes sulphurous acid when dissolved in water is the most poisonous. It is a powerful deoxidising agent, and probably acts directly on the protoplasm, entering the cells through the stomata of the leaves. The action is slow but sure, and it is interesting to note that the plant has time to withdraw its starchy stores into the stem from the leaf, which then drops as it would in the autumn. After several days of fog, when sulphurous acid fumes are excessive, there is a great shedding of leaves, which have been tested on several occasions and found to be almost destitute of starch.

Sulphuric acid is another poisonous constituent of smoke. It acts as a caustic, always withdrawing water from foliage cells to replace any lost by evaporation of itself. The result on foliage is that of scorching. The rain that should cleanse the plant, at the same time brings fresh supplies of the acid, washed from the air.

But it is the solid deposits that most visibly affect foliage. Everyone is familiar with the sooty appearance of town gardens. The deposit acts harmfully in two ways; first, it darkens the epidermis and cuts off the light rays without which the green chlorophyll cannot perform its functions; secondly, it clogs the pores of the leaves, arresting transpiration, and the absorption

of nutrient gases. Leaves that have definite upper and under surfaces have their stomata on the under side, and the clogging is minimised, but such trees as conifers, with stomata on both sides, and sunk in pits as well, soon become choked. The oily matter which is another product of partial combustion of coal, clings very closely, and rain has hardly any cleansing effect where there is an oily deposit.

The damage to foliage is so striking that the damage to soil by the same agents is often overlooked. Soil has its own germ life, which if interfered with fertility is affected. The extraordinary benefit to town soil from a dressing of lime shows how excessive is its acidity. The oily, sooty deposits cut off all benefits from aeration, and without oxygen chemical action ceases and root action is checked. Shrubs planted in a ball of soil in the Bank of England garden at the end of a year had not put out a single root into their new environment. Bulbs make less roots than if they were planted in fibre, while grass merely roots on the surface, clinging to every chance of air, and is so lightly attached that a broom would brush it off like the nap from shoddy cloth.

Apart from the question of deposits and poisons is that of deficient illumination, which prevails in towns from the beginning of November to February. The mere withdrawal of light induces partial starvation, and transpiration is also checked. But warmth and water enable the roots to continue their work, and consequently the cells of the plant are distended with water, the machinery is out of gear, and the plant is a ready victim to any disease.

Some very interesting observations as to the lowered vitality of town vegetation are published by Mr. Arthur G. Ruston in the September *Monthly Magazine and Circular* of the North of England Horticultural Society. The observations are on ash trees in the Leeds district, where he finds that some trees throw off their leaves from four to six weeks earlier than others, owing to poisonous gases. "Thus, during the autumn at Roundham, with total suspended matter 90 lbs. per acre, and acidity nil, ash trees were found in full leaf on November 17. At Weetwood Lane, with suspended matter 9·147 lbs. and acidity equal to 11 lbs. of sulphuric acid per acre, the leaves had all fallen before the end of October; at Kirkstall, with suspended matter 352 lbs. and acidity 8 lbs. per acre, one ash only could be found in leaf on October 5; whilst at Headingley, with suspended matter 659 lbs. and acidity 11 lbs. per acre, all leaves had fallen from the ash trees at that date. On September 28 of this year (1911) in Hunslet, with suspended matter 1,565 lbs. and acidity 90 lbs. per acre, all of the ash trees which were alive were found to have shed their leaves." This is a valuable record of the baleful effect of impure atmosphere.

In London it is very noticeable how premature is the shedding

of soft foliaged leaves, such as limes. Taking the average time a tree is in full leaf as five months, it is a serious loss to it to be deprived of six weeks of its manufacturing period. No wonder town trees are sickly and stunted in growth! And the pity of it is that vegetation is the natural antidote to the exhaustion of the air by animal life.

We may now consider the type of tree best suited to exist in poisonous and dirty air. It should be deciduous, entirely renewing its foliage annually. Evergreens accumulate dirt and are exposed to the worst months of the year. The foliage should be hard, shiny, and carried horizontally (this applies equally to herbaceous plants), and if the leaves develop late, when spring winds and lessened fires make for purer air, so much the better. The plane tree has every qualification for town life except its great size, and though planted extensively we too often see the trees crippled by being cut about to make them fit a limited space. Such full-grown specimens as we have in London, in Berkeley Square, for example, are in splendid health. The leaves come late, and are very firm in texture and so able to resist poisonous fumes. They are borne horizontally, and are the less liable to have their stomata clogged by soot. The surface is glossy and deposits collect with difficulty, and are more readily washed off by rain. All foliage is annually renewed, and, what is more unusual, the bark also sheds the outer layer, and the breathing pores in the stem are left clean. The nearer a tree or shrub approaches to the nature of a plane the better it will thrive in a town. In the Black Country, where experiments are being made to plant the spoil heaps from pits and furnaces, the common alder has been found the most useful. Here, again, the hard smooth leaf is a large factor in success. Planes require more sustenance than refuse heaps can supply, but when the alder has made a beginning the plane will probably follow.

Air Pollution by Coal Smoke and its Effects on Vegetation.

By Arthur G. Ruston, B.A., B.Sc.
(Department of Agriculture, The University of Leeds).

Among the many subjects that in recent years have engaged the attention of those interested in the improvement of the public health of our city communities, the question of atmospheric pollution has obtained a place which is slowly gaining in importance. The subject is commonly discussed, however, as if the pollution were rigidly confined within the municipal boundaries, and solely of importance in its bearing upon the health of the ratepayer and the appearance and durability of his property. It must, however, be apparent even to the casual observer on his approach to the town, that the question has a significance for the agriculture and horticulture of the neighbouring semi-urban districts which cannot altogether be estimated, but which must be very great. This aspect has been, as yet, but little investigated, or even discussed, and it is with a view to calling your attention to the undoubted damage done by smoke pollution to vegetation in general, and to your own garden in particular, that I venture to bring before your notice some of the work that we have been doing in this direction.* Professor Cohen has for the last twenty years been busily engaged in collecting invaluable information and data with reference to smoke pollution. Some five years ago Dr. Crowther and myself turned our attention to the effect of this pollution on plant life,† and we have found it a most fertile and fascinating field of research.

That this pollution is always with us can readily be seen by taking a bird's-eye view of any of the industrial portions of Leeds. Here chimney after chimney is seen belching out smoke and blackening the whole neighbourhood, while much of the smoke thus turned out is carried for miles before finally being deposited.

But it is not altogether the manufacturers who are to blame, though undoubtedly they are great offenders. Every house, every private chimney is sending out its own small quota, and the accumulated effect of all this is an atmospheric pollution which is simply appalling.

My earliest investigations with regard to the nature and extent of air pollution by coal smoke were undertaken in con-

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* Cohen and Ruston, *Nature*, Oct. 14, 1909, and *Journal of the Society of Chemical Industry*, Dec. 15, 1911.

† Crowther and Ruston, *Journal of Agricultural Science*, iv. 25.

nection with a three years' series of analyses of rain samples collected at the Manor Farm, Garforth (experimental farm of the University of Leeds and Yorkshire Council for Agricultural Education). The most extensive series of analyses of rain that have been made in this country are those carried out at Rothamsted. According to the results there obtained, the yearly rainfall carries down at Rothamsted atmospheric impurities on the average roughly equal to 4 lbs. of nitrogen, 15 lbs. of chlorine, and 18 lbs. of sulphuric acid per acre. The Rothamsted results may probably be taken as typical of the rain falling in the essentially rural parts of the country, fairly remote from the sea, but will not hold good for the large tracts of agricultural land situated in the smoke-infested localities so extensive in area in many parts of the country. With a view to supplementing the meagre information available as to the composition of rain falling in such districts, the collection of samples of rain was commenced at the Manor Farm, Garforth, in October, 1906, and continued without interruption until the close of the year 1909. The farm is situated on the outskirts of the urban district of Garforth, some six miles due east of the great industrial city of Leeds, and on the north-eastern edge of the Yorkshire coalfield. The prevailing winds are westerly, and hence convey much of the impurity of the Leeds atmosphere over the farm. There is further local contamination from the coal-mining districts to the south and south-west, more particularly from two collieries situated respectively about one mile and half a mile from the centre of the farm.

Owing to its close proximity to these collieries and to the drift of the smoke from Leeds, we find that the average deposit of nitrogen was 8½ lbs. per acre as compared with 4 lbs. at Rothamsted; the annual precipitation of sulphuric acid was 96 lbs., or more than five times the average at Rothamsted, while 26 per cent. of the total sulphur compounds were in the form either of sulphites or sulphides, a proportion which is indicative of high local contamination by coal smoke; and the average annual deposit of chlorine was 21 lbs. per acre, nearly 50 per cent. higher than the Rothamsted figure. The impure nature of the Garforth atmosphere is strikingly illustrated by the amounts of free acid brought down by the rain, the average amount being equivalent to 20 lbs. of sulphuric acid per acre yearly.

The extensive smoke pollution of the Garforth atmosphere, as revealed from the very outset of the investigations, suggested a diagnosis upon similar lines of the atmosphere in various parts of the neighbouring city of Leeds, which might fairly be regarded as responsible for some, if not, indeed, for the greater part, of the impurities.

Accordingly ten representative stations were selected in localities of different types, ranging from the markedly industrial to the purely residential suburban quarters. During

the year—November, 1907, to October, 1908—samples of all the rain falling at these stations were periodically collected and analysed. The rain in each case was collected by means of funnels, 12 in. in diameter, connected with glass reservoirs, which were emptied once a month. The monthly samples, therefore, include all atmospheric impurities, both soluble and insoluble, falling on a circular area of 12 in. diameter, whether actually brought down by the rain or falling at other times. These impurities may be divided for convenience into, first, those in suspension, consisting of soot, tar, sand, and mineral matter ; and second, those in solution, such as sulphur compounds (chiefly sulphurous and sulphuric acids in their salts), chlorides (largely in the form of hydrochloric acid or common salt), and nitrogenous matter in the form of nitrates, ammonia, and organic matter.

The following table gives the amount of these impurities annually reaching the ground, whether actually brought down by the rain or falling at other times.

TABLE I.

ANALYSIS OF RAIN WATER, LEEDS AND GARFORTH.

Total for Year, November, 1907, *to October,* 1908, *expressed in Pounds per Acre.*

—	Collecting Station.		Suspended Matter	Tarry (Ether-soluble) Matter	Mineral Matter	Free Acidity as H_2SO_4	SO_3 (Total Free and Combined	SO_2	Chlorine	Nitrogen as NH_3	Nitrogen as N_2O_5	Nitrogen as Albuminoid Ammonia	Total Nitrogen
1	Leeds Forge . .	Industrial	1,886	110	1,113	35	123	34	164	13·0	0·0	4·7	17·7
2	Hunslet . . .	Industrial	1,565	69	655	90	185	24	198	15·5	0·0	2·9	18·4
3	Beeston Hill . .	Industrial	1,163	149	709	30	269	54	101	14·4	0·5	3·5	18·4
4	Philosophical Hall	Industrial	849	78	423	45	149	38	75	14·4	0·3	2·2	16·9
5	Headingley . .	Residential	659	43	199	11	118	32	41	11·1	1·1	0·8	13·0
6	Armley . . .	Residential	593	34	216	29	110	37	108	9·9	1·0	3·2	14·1
7	Observatory . .	Residential	399	32	146	26	85	39	51	8·4	0·8	1·6	10·8
8	Kirkstall . . .	Residential	352	28	141	8	77	56	57	7·7	0·2	2·3	10·2
9	Weetwood Lane .	Residential	147	26	54	11	82	13	34	8·3	1·1	2·1	11·5
10	Roundhay . . .	Residential	90	14	49	0	53	16	38	5·8	0·7	1·3	7·8
11	Garforth . . .	Country	—	—	—	28	65	21	22	5·0	3·2	1·1	9·3
12	Garforth (average three years).	Country	—	—	—	20	70	21	21	6·4	1·9	1·4	9·7

Leeds lies on the north-eastern fringe of the Yorkshire coalfield, the industrial area being almost entirely confined to the southern half of the city, whilst other industrial towns and coal mining villages lie not far distant on this side in all directions, ranging from south-east round by south to west. To the north and east the city merges into a vast tract of purely agricultural country. The local character of the solid impurities is well illustrated, therefore, by the fact that they diminish rapidly as we pass northwards from the centre of the town. Thus at

Station 4 (Philosophical Hall), in the centre of the town, they represent roughly 850 lbs. per acre, whilst at Station 7 (Observatory), less than a mile away to the north, they fall to 400 lbs. per acre, or less than one-half, and at Station 9 (Weetwood Lane), some two and a half miles to the north, they represent only 150 lbs. per acre, or little more than one-sixth of the deposit in the centre of the town.

The influence of the industrial centres upon the amount of these solid impurities stands out most conspicuously, for at Station 1 (Leeds Forge) they amount to nearly 1,900 lbs. per acre, and at Station 2 (Hunslet) to 1,550 lbs., as compared with 90 lbs. at Station 10 (Roundhay). In other words, in the chief industrial centres of Leeds the solid impurities are roughly twenty times as abundant as in the purer atmosphere of Roundhay, some three miles due north-east of the centre of the town.

The prevailing winds are west and south-west, and we should naturally expect, therefore, that the general drift of the impurities will be more towards the east than towards the west. This is specially evident in the case of Stations 5 (Headingley) and 8 (Kirkstall). Both are roughly the same distance from the centre of the town, both lie to the north-west, both overlook the industrial Kirkstall section of the Aire Valley; Station 5 (Headingley) from the east, however, Station 8 (Kirkstall) from the west; with the result that the solid impurities at Station 5 (Headingley) amount to 660 lbs. per acre as against 350 lbs. per acre at Station 8, in a corresponding position on the opposite side of the valley.

Of the three constituents of the total suspended matter, the one we should regard *à priori* as least injurious in its effects upon vegetation is the ash or mineral matter, though from a health point of view medical men might hold a different opinion.

This will be seen to be remarkably high at Station 1, which was situated in the grounds of the Leeds Forge Company's works, the ash deposited there representing no less than 1,100 lbs. per acre per annum. It consists principally of oxides of iron, alumina, lime and silica, either escaping with the fumes from the furnace or thrown out mechanically by the blast. As an indication of the amount of grit that is thrown out in this way, it may be stated that one large engineering firm in Leeds some time ago fixed to two of their chimneys an apparatus for collecting the greater part of the grit. The result was the accumulation of about 15 cwts. per week from the two chimneys.

Much more objectionable, from our point of view, is the *soot*. Soot applied to the soil, once in a rotation, as a fertiliser, may be, and is, of considerable value, but when continuously and generously applied to the leaves of plants its effects are quite different and eminently undesirable.

Some idea, too, of the enormous waste of fuel may be gathered from the fact that our results indicate that at Station 2 (Huns-

let) the soot actually deposited amounted to 300 tons per square mile per annum ; at Station 1 (Leeds Forge), to 250 tons ; at Station 3 (Beeston) and Station 4 (Philosophical Hall) to 150 tons ; and at Station 7 (Observatory) to 80 tons per square mile per annum. Taking the average of these five stations, all of which lie within the central 4 square mile area, we arrive at an average of 190 tons per square mile per year, or roughly half a ton per square mile per day of soot actually reaching the ground, while at least ten times this amount is thrown into the atmosphere.

Most objectionable of all the suspended impurities, as far as the plant is concerned, is the tarry matter. At all stations an appreciable amount of tar was found in the suspended matter, the amount being greatest in and near the industrial area, and diminishing rapidly towards the north. Thus at Station 4, in the centre of the town, the yearly deposit of tar amounted to 80 lbs. per acre ; one mile to the north, at Station 7, it was 32 lbs., or less than one-half ; whilst at Station 9, two and a half miles to the north, it fell to 25 lbs. ; and at Station 10, three miles to the north-east, it amounted only to 14 lbs. It is interesting to note, however, that the suspended matters in the suburban areas, though smaller in amount, are much richer in tar than those of the industrial areas. Thus, whereas at the suburban stations, 9 and 10, the tar formed 17 and 15 per cent. respectively of the total suspended matter, the proportion in the case of the industrial stations, 1 and 2, was only 6 and 4 per cent. respectively. There is thus a characteristic difference between the contamination arising from the factory shaft and that attributable to the very imperfect combustion of the domestic range.

These solid impurities present in the air, and due to pollution by coal smoke, play a very important part in detrimentally affecting the growth of plants. Their effect in diminishing the amount of sunlight in our industrial towns may be gathered from the fact that in 1907 the number of hours of bright sunshine registered at station 4, in the centre of Leeds, was 1,167, as compared with 1,402 at Adel, some four miles to the north. In other words, the smoke cloud hanging over the centre of the city curtailed the duration of bright sunshine by fully 17 per cent. That the records of other years tell a similar tale can be seen by glancing at the following table, where the percentage of sunshine recorded at Station 4 is compared with that recorded at Adel, Adel being always reckoned as 100 :—

Year.	Per cent.	Year.	Per cent.	Year.	Per cent.
1890	69·3	1896	76·0	1902	82·4
1891	69·9	1897	83·5	1903	87·5
1892	69·0	1898	79·1	1904	87·7
1893	77·1	1899	82·8	1905	87·2
1894	82·2	1900	78·0	1906	87·5
1895	84·0	1901	85·5	1907	83·0

But the ordinary sunshine recorder simply registers the number of hours when the sunlight exceeds a certain fixed intensity, and gives little or no indication as to whether the intensity of the light so registered was little or much above the arbitrarily fixed standard. If the actual intensity of the light be measured still greater differences may be expected. Such measurements were carried out daily from November, 1895, to February, 1896, by Professor Cohen at three stations in Leeds. The method employed was to expose a mixture of 50 c.c. of a 1 per cent. solution of potassium iodide and 10 c.c. of dilute sulphuric acid and titrate the iodine set free against a decinormal solution of sodium thiosulphate. The amount of iodine set free would be roughly proportional to the intensity of the light. Professor Cohen's results showed that in the busy manufacturing centres the smoke absorbed about 25 per cent. of the total daylight. These daylight tests have been repeated simultaneously at six of our stations for more than a month, and the results show a striking correlation between the amount of suspended matters in the air and the intensity of the light. If the stations be arranged in *descending* order with reference to the amount of solid impurities, this is precisely the *ascending* order with reference to the intensity of the light. Thus at Station 2, where the suspended matter deposited in one year corresponded to 1,500 lbs. per acre, the intensity of the light was only sufficient to liberate daily an amount of iodine corresponding to 3·2 c.c. of $\frac{N}{10}$ thiosulphate, whilst at Station 9, where the suspended matter corresponded only to 150 lbs. per acre, the iodine liberated daily from a similar solution corresponded to 5·4 c.c. of $\frac{N}{10}$ thiosulphate. In other words, the intensity of the light, as measured by the amount of iodine set free, may be represented for Station 9 by the arbitrary number 54, and on the same scale the intensity at Station 2 would then be represented by 32; that is, at the latter station in one of the chief industrial areas the smoke cloud shuts off fully 40 per cent. of the actual light. It may be urged that the iodine method only measures the variation in the intensity of the chemically active radiation at the violet and ultra-violet end of the spectrum, and that these results do not necessarily hold good for the less refrangible rays at the other end of the spectrum, which are all important as far as the photo-synthetic work of the plant is concerned. On discussing this point with Professor Bragg, he expressed the opinion that in all probability the absorption by smoke would be much the same for rays of all wave-lengths. On actually measuring the co-efficients of absorption for red and violet light respectively of two suspensions of soot, it was found that the absorption was distinctly higher for the red than for the violet light. Taking the absorption for the violet

light as 100, the absorption for the red light was 120 and 125 respectively for the two suspensions of soot. The effect of all this curtailment of light upon vegetation is only too obvious in the stunted vegetation—such little as survives—of the badly polluted areas. The energy of sunlight is required by the green leaf for the conversion of carbon dioxide into carbo-hydrates, and when 40 per cent. of this energy is cut off by the smoke cloud, the effective growth of the plant must be very considerably checked.

But the reduced supply of light is by no means the only injurious effect of smoke upon plant growth. The leaves become coated over with a thick black deposit which will still further tend to shut out the light and hinder the chlorophyll in its work. Naturally, the greater the pollution of the air by coal smoke the greater will be the deposit upon the leaves. I have no available data with reference to the amount of such deposits upon leaves taken from different parts of Leeds, but Professor Cohen has given me the following results of observations taken in Manchester. The figures express in milligrams per square metre of leaf surface the solid deposit found on aucuba leaves taken from the localities named.

	Locality.	Deposit.
Urban	Infirmary (holly leaves)	728
	Infirmary (aucuba leaves)	568
	Albert Square (aucuba leaves)	833
Suburban	Harpurhey	443
	Hulme	420
	Owens College	315
	Peel Park	374
	Queen's Park	194
	Alexandra Park	131

Again, the greater part of the material of which the plant is composed is taken from the atmosphere. The leaves of plants possess minute pores or stomata, by means of which they absorb carbon dioxide from the air, this carbon dioxide being converted in the plant into starches, sugars, or other carbohydrates. Anything, therefore, which will tend to hinder this intake and assimilation of carbon dioxide will effectively hinder the growth of the plant. Now soot, as can be seen from the table on page 36, is not pure carbon, but contains varying amounts, occasionally as much as 40 per cent., of a thick oil or tar.

This adhesive tarry matter present in the deposit will cause it to adhere tenaciously to anything with which it may come into contact, so that it cannot easily be removed by the rain. It will cover the whole of the leaf with a kind of varnish, and fill up the pores or stomata, most effectively checking the natural process of transpiration and assimilation. True, the stomata, in the case of most plants, are situated on the under side of the leaf, while the greater part of the grime will naturally settle upon the upper surface. Still, a microscopic examination of the lower surfaces of the leaves of many plants shows that they by no

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means escape unhurt. Evergreens suffer most in this respect, because they have also the winter smoke to contend with. Of the evergreens the most susceptible seem to be the conifers.

PERCENTAGE OF TAR FOUND IN VARIOUS SAMPLES OF SOOT.

Source of Soot.	Percentage of Tar.	Condition under which Coal was burnt.	Position in Chimney.	
University . .	25·9	Domestic.	Base.	
,, . .	0·09	Boiler.	,,	
,, . .	0·80	,,	70 ft. up.	
,, . .	1·66	,,	Top.	
Brass Foundry .	1·02	,,	Base.	Using liquid fuel.
,, ,, .	10·62	,,	Top.	
North Grange Rd. .	10·20	Kitchen grate.	Base.	Domestic.
,, ,, .	15·68	Study grate.	Base.	
Winston Gardens .	12·5	Kitchen grate.	,,	
,, ,, .	34·9	Dining-room grate	,,	
,, ,, .	40·4	,, ,,	Top (35 ft.)	

These trees are xerophytic, their natural habitat is in a pure atmosphere at a high altitude, where the winds are high and the barometric pressure low, and where consequently evaporation from the leaf surface will be great. The soil, however, will be shallow and the roots none too plentifully supplied with moisture, and hence there will be a constant necessity to husband the water supply as far as possible. This end has been effected in the evolution of the plant by the double device of small leaf surface and sunk stomata. Thus, in the case of the silver fir the stomata are bottle-shaped with a narrow neck, and in the juniper, when viewed from above, cells rise like four walls, forming a kind of hollow, at the bottom of which lie the stomata proper. Both of these forms afford very efficient protection against undue evaporation, but also form very efficient traps for smuts and dirt, when the trees are situated in atmospheres such as those of large industrial towns. Conifers planted in Hunslet, with a total deposit of suspended matter equal to 1,565 lbs. per acre per year, I have seen completely killed in less than three months. Some three years ago about twenty conifers were planted in the grounds of the university close to Station 7, with an annual deposit of 399 lbs. of suspended matter per acre. At the present time not one of those is alive. The only two localities in Leeds in which conifers attain even moderate growth are those around the two stations which stand out clearly as possessing the purest atmospheres, viz., stations 9 and 10. It is doubtful if they could do well in any district where the suspended impurities deposited yearly amount to 200 lbs. per acre.

If the plant obtains the greater part of the material of which it is composed from the air through the assimilation of carbon dioxide, the measurement of that assimilation on a unit area

of leaf in unit time should give its measurement of effective growth. Again, if that assimilation takes place through the stomatal openings, and if the stomata are often choked with the tarry deposit upon the leaf—cases where the leaves of conifers grown in Leeds have 80 per cent. of their stomata thus choked being frequent—we should naturally expect, the larger the amount of these solid impurities present in the air, the smaller would be the relative powers of assimilation of carbon dioxide possessed by leaves taken from such an area. In other words, the greater the solid impurities present in the air, the smaller and more stunted we should expect plants and trees from that area to be.

It was interesting, therefore, to compare this assimilation in the case of laurel leaves of the current year's growth, grown in different parts of Leeds. Taking those grown in Weetwood Lane as our standard, it was found that on the same day, with the same temperature and the same intensity of light, the assimilation of different leaves from the same locality was approximately constant. If, however, we take leaves from the same locality, then rates of assimilation will vary day by day, depending upon the temperature and intensity of light. The smoke cloud, therefore, continually hanging over our industrial areas, by shutting out the direct radiation and so tending to reduce both the temperature and intensity of light, will exert in this respect a very marked influence in limiting the growth of plants.

If, again, we compare on the same day the assimilation of leaves grown in the Weetwood Lane and in some more impure districts, we always find the leaves from the purer district possess the greater power of assimilating carbon dioxide. Using this as our measurement of the growth of plants from different districts, we can give them the following values :—

Station.	Annual Deposit of Soot.	Assimilatory Powers.
Weetwood Lane	147 lbs. per acre.	100
Headingley Hill	273 ,, ,,	53
University	399 ,, ,,	42
City Square	849 ,, ,,	12

As was to be expected from the above figures, the laurel plants found in the more polluted areas were all stunted in size, as compared with those grown in the Weetwood Lane district, while in Hunslet, one of the most polluted areas, a two days' search failed to find any trace of laurels which had survived the ordeal.

In order to test the effect upon the rate of assimilation of the actual deposit found upon the leaves, the leaves taken from the City Square were again compared with the standard leaves,

after carefully cleaning their surfaces with a dry cloth. The results may be summarised as follows :—

Station.	Assimilatory Powers.
Weetwood Lane	100
City Square, leaves clean . . .	19
,, ,, leaves dirty . . .	12

The effect was thus distinctly measurable, although the assimilatory powers of the cleaned leaves still remained far below that of the leaves grown in the purer atmosphere of Weetwood Lane.

With regard to the soluble impurities, it may be stated that the majority of the samples of rain collected at the different stations were decidedly acid to methyl range, indicating the presence of free mineral acid, probably mainly sulphuric acid, arising from the combustion of coal. The distribution and amount of this acid are somewhat erratic, owing to the presence in the atmosphere also of impurities of alkaline reaction. Thus the marked discrepancy between the acidities of the rain at the two main industrial stations, Leeds Forge and Hunslet, is attributable to the large amount of alkaline impurities emitted by the furnaces near which the former station was located. At this station, indeed, the rain was in many cases appreciably alkaline in reaction. It is not, however, difficult to trace some degree of correlation between industrial activity and atmospheric acidity.

Station.	Total Suspended Matter.	Total Sulphur Compound.	Free Acid.
Leeds Forge . .	1,886 lbs. per acre	157 lbs. per acre	35 lbs. per acre
Hunslet . . .	1,565 ,,	209 ,,	90 ,,

Free acid must be actively detrimental to vegetation, both by its direct action upon the leaves, and by its slower action upon the soil. The deposition of acid along with soot upon the leaves of plants is probably one of the main causes of the early withering which is so characteristic of many forms of town vegetation, notably trees. Ash trees in the purer parts of Leeds will retain their leaves some four, six, and even in some cases eight weeks longer than those in the more contaminated districts. Thus, on September 18 of last year, in Hunslet, with suspended matter 1,565 lbs. and acidity 90 lbs. per acre, all the ash trees which were alive were found to have shed their leaves ; while at Roundhay, with suspended matter 90 lbs. per acre and acidity nil, practically all the ash trees were in full leaf at the beginning of November.

If, therefore, we look upon the leaf as the factory of the plant, we find that, owing to the smoke pollution, the factory is actually

closed for six weeks out of the four or five months of its working year, while during the remainder of the time, as our assimilation experiments show, it will be working at less than half its normal pressure.

With the object of ascertaining the effect of free acid on plants, grasses have been grown for three years under cover, under exactly similar conditions, except with regard to the water supplied. These were watered at rates corresponding to the average rainfall of 25 inches, with Garforth rain water neutralised, Garforth water unneutralised, Leeds rain water (the acidity of which varied from $\frac{1}{2}$ part to occasionally as much as 10 parts per 100,000); and also with water containing 1, 2, 4, 8, 16 and 32 parts per 10,000. In early September of each year, the grasses were cut, dried, weighed and analysed. It was shown that while the final effect of acidity was to destroy vegetation altogether, smaller amounts had the effect of reducing both the quality and quantity of the herbage. Thus in every case, a larger amount of acidity meant a decreased yield; an increased fibre content indicating that the grasses were indigestible, and a decreased protein or albuminoid content indicating a low feeding value. It becomes, therefore, a matter of the highest interest and importance to ascertain if, and to what extent, such deterioration can be traced on the large scale in meadows of smoke-infested areas. The injurious effect of this acid will be partly direct and partly indirect through its action on the soil. The effect of the acidity in the soil was shown most markedly in the reduction in the number and activity of the micro-organisms in the soil, of which the most valuable, and at the same time the most sensitive, are the nitrifying organisms. Since bacteria play an all-important part in influencing the fertility of the soil, this suggests still another way in which smoke pollution may damage vegetation.

The other sulphur compounds were everywhere high, but notably so in and near the chief manufacturing areas. The bulk of the sulphur was present in the form of sulphuric acid or sulphates, though in every case an appreciable amount was also present in lower forms of oxidation (e.g., SO_2, SH_2), these being highly toxic in character as far as vegetation is concerned. The extent of smoke pollution in Leeds may be gauged by the fact that in the industrial areas we get an annual deposit of sulphur compounds equivalent to 336 lbs. of SO_3 per acre, as compared to 18 lbs. at Rothamsted. These sulphur compounds will be first liberated from the burning coal in the form of sulphur dioxide or sulphuretted hydrogen, which gases, entering the leaves through the stomatal openings, become probably one of the greatest sources of injury to the plant. It is in all probability due to this cause, that we so often find trees and vegetation destroyed wholesale in the immediate neighbourhood of coal-mines, brick-fields and coke ovens. In consequence of this,

it is to a large extent possible to get some idea of the extent of smoke pollution in any particular place, by comparing the sulphur content of leaves of trees taken from that locality with similar leaves taken from a place where the atmosphere is known to be pure.

The following analyses give an indication as to what extent smoke pollution can be correlated with the sulphur content of leaves :—

Locality.	Percentage of SO_3 in Original Leaf.
Spruce Leaves :—	
Roman camp, near shale retorts	0·28
Ecclesmachan, country village, in the neighbourhood of shale works	0·12
Near Dumfries, open country	0·07
Scotch Fir :—	
Roman camp	0·19
Near Dumfries	0·06

For the above I am indebted to Mr. D. R. Stewart.

Locality.	Suspended Matter.	Total Sulphur Compounds (SO_3).	Per cent. of SO_3 in Dry Matter.		
			Radishes.	Lettuces.	Ash.
	Lb. per acre.	Lb. per acre.			
Hunslet	1565	215	2·52	3·22	1·81
Park Square . . .	849	197	2·77	2·61	—
University . . .	399	134	1·78	1·99	1·62
Headingley Hill . .	220	104	1·98	2·02	1·49
Weetwood Lane .	147	98	1·99	1·53	1·41
Garforth	—	91	1·88	1·20	—

Chlorides are also found in large quantities, especially in the industrial areas, where expressed as common salt they sometimes represent a deposit amounting to three or four cwts. per acre, at which rate they must be distinctly prejudicial to vegetation. Throughout the semi-industrial and non-industrial area the amount was not more than about 50 lbs. per acre, with the exception of Armley, where the total reached 108 lbs. This high figure finds an explanation in the salt glazing process carried on at a neighbouring fire-clay works. The local origin of the bulk of the chlorides is evident from the fact that they diminish rapidly in quantity as we pass northwards from the centre of the city. Moreover the average chlorine content of the samples collected at the industrial station of Hunslet was about 35 parts per million, or nearly ten times the proportion found in the rain falling in rural districts. An excess of chlorides, taken alone, is no proof of a contaminated atmosphere, for they naturally increase in quantity as we approach nearer the sea; but an excess in an inland place, above the amount in the district surround-

ing it, is a certain proof of impurities being thrown into the air. Of the 200 lbs. of chlorine per acre deposited each year in Hunslet, some 20 lbs. may most probably be put down as being due to natural causes, such as the spray from the sea ; and the remainder as being the result of local impurities derived from the blast furnaces, glass, glazing works and potteries, as well as from the coal itself. Undoubtedly coal smoke is to a very large extent answerable for the large amount of chlorides found in the atmosphere of industrial towns, for coal itself contains roughly 0·25 per cent. of chlorine, and a domestic soot will contain on an average 5 per cent., and occasionally as much as 9 per cent. of chlorine, while the chlorine content of a factory soot will vary from ·1 to 1·5 per cent.

The nitrogenous impurities may all be regarded as distinctly beneficial to vegetation, either acting as direct fertilisers, or neutralising the acidity due to the presence of sulphur or chlorine compounds. They would be derived principally from the nitrogen originally present in the coal, partly also from decomposing organic matter, and to a small extent from the direct oxidation of the free nitrogen in the air. There is not in this case the great variation in the amounts in different parts of the town that we get with the other impurities ; the highest amount representing 18 lbs., and the lowest 9 lbs. per acre. It is, however, interesting to note that nitrogen in the form of nitrates is found only in the purest localities, and that the organic nitrogen is found in largest quantities in the industrial areas.

In conclusion, I would point out that the main detrimental effects of air pollution by coal smoke upon vegetation are :—

(1) The cloud of smoke blocking out the sunlight, and thus reducing the available solar energy by in some cases 40 per cent.

(2) The thick deposit on the leaves of plants and trees, still further blocking out the light.

(3) The choking of the stomata by the tarry, glutinous matter, thus tending to asphyxiate the plant, and effectively checking its power of assimilation of carbon dioxide.

(4) The presence of free acids falling on the soil, which certainly, as far as grasses are concerned, diminish the yield, make them less digestible, and in other ways lower their feeding value, while they have also a very detrimental effect on the bacterial life in the soil.

(5) The presence of free acids in the air, tending generally to lower the vitality of the plant.

The first three can only be effectively dealt with by limiting the output of smoke, while the fourth can, to a large extent, be overcome by a judicious application of lime.

The Aims and Works of the Hamburg Abatement Society.

By Herr Oberingenieur E. Nies

(Chief Engineer, Hamburg Smoke Abatement Society).

In 1905 Mr. Kershaw gave you a report respecting the work and aims of our Society on the occasion of the Smoke Abatement Conference held in London in that year.

The successful development experienced by the Society in the first years of its existence has continued, so that it has been enabled to extend its operations to a large part of the industrial districts in the neighbourhood of Hamburg. Its work has even been well received outside of Germany itself. The "Vereeniging tot Bevordering van rookvrij Stoken," in Amsterdam, has formulated its statutes on a basis similar to that of our own Society, and the Chief Manager, Mr. de Kuyser, has been able to communicate in his two annual reports much that is interesting about his work.

An independent Society was founded in Helsingfors in 1911 in order to carry on the work begun by us in Finland, under the guidance of Mr. Göhner, one of our former engineers, who is following up our aims.

The Hamburg Society has 328 members who use boilers, besides 102 other members who support the Society, and it supervises 1,345 boilers in the interests of members.

There are three engineers and five instruction stokers occupied in the plant of members, under the direction of the head engineer.

Boiler plant in Hamburg, or its immediate neighbourhood, is inspected three times a year. Such inspections last one or several days according to the size of the plant to be examined; their purpose is to instruct stokers in testing existing apparatus for the control of stoking, and to control the structural conditions of the plant with regard to economy and smoke abatement.

As a rule a written report is drawn up for each inspection, and in it suggestions are given for improvements, as also advice with regard to the purchase of fuel, procuring furnace parts, and the like.

A special Institute has been created by the Society for the chemical and calorimetrical examination of the fuel used, namely, the Thermochemical Analysis and Testing Institute of Dr. Aufhäuser, which has at its disposal a very wide selection of material for examination of both German and English fuels, owing to the large importation of English coal into Hamburg.

There are also many small trade installations connected with the Society, such as, for instance, the plant of bakeries, steam heating of houses, &c. Further installations on board ships have often been examined, and the experiences gained in land plant has been applied to them also.

The Society has become known in wider circles through its publications.

Just at the time when Mr. Kershaw made his report on the work of the Society in 1905, important experiments were in progress with a view to elucidate the relations that exist between the development of smoke and the utilisation of fuel. It may be a matter for surprise that any further investigations should have been requisite on this particular point, in view of the fact that so much has already been done in this field, and yet the experiments carried out demonstrated that the opinions hitherto ruling with regard to the prevention of smoke would have to be somewhat modified. The main principle of former times, namely, "Have a sufficiently high temperature in the combustion chamber," was obliged to yield its place to another capital requirement: "For perfect combustion there must be a sufficiency of air in the due proportions required."

The reasons for adopting the principle of a due supply of air as the main requisite for a successful restriction of smoke have been exhaustively treated in the "Investigations in Fuel and Firing Combustion," published by the Society in 1906 on the occasion of the experiments mentioned above.

The results there described have also been accepted as the basis for the work prepared in the year 1910 on behalf of the Society of German Engineers, entitled, "Boilers: Firing so as to obtain a Minimum of Smoke Production."

Under the participation of the Society, the Journal "Smoke and Dust" was started last year, and has already acquired a wide circulation.

The principle of doing a thing oneself has been adhered to faithfully by the Society. Legal measures always involve certain hardships towards industry, the more so as there is no longer any doubt that a large portion of the damage caused by smoke is to be brought home not to the firing of trade concerns, but to the firing of individual households.

The Society owes its progress in the first instance to aiming at the greatest possible utilisation of fuel, together with the highest practicable degree of perfect and smokeless combustion.

Laymen are apt to think that the loss in fuel occasioned by the smoke lies in the soot visibly streaming from the chimney stack. But this is not the loss which is of material consequence in the complete utilisation of fuel; this loss resides in the unburnt gases, which cannot be estimated by a mere observation of the development of the smoke. Much more is needed to gain a correct estimate of the loss sustained through incomplete combustion than a mere observation of the smoke, as also to properly estimate the loss of fuel in firing generally. Researches are also requisite with regard to the composition of the waste gases in order to determine the losses through radiation, as well as those occasioned by imperfect combustion. It is well known that the caloric force that is lost in most plants is of far greater importance than the loss through smoke as a factor in the complete utilisation of fuel.

This work, *i.e.*, the proper examination of fuel, encountered great difficulties until suitable instruments had been invented, and it was a task of the utmost importance to devise such instruments and to procure for them admission into the trade, as it was by their means that the stoker's work could be estimated and his interest aroused by the promise of a bonus, according to the results shown by an examination of the waste gases. In this connection the Society makes use of instruments or apparatus in its investigations based on the principle of collecting average samples. These average samples are examined at the end of every shift, and the stoker paid accordingly.

Whenever the owner of firing plant can be convinced that the proposals laid before him by the Society are to his pecuniary advantage, he will always be found willing to entertain the suggestions of the Society for the prevention of smoke.

In many cases the part played by the stoker in smoke prevention is over-estimated. Undoubtedly, economical firing rests mainly with the stoker, but the avoidance of smoke is less the work of the stoker than the manner in which the firing is carried out. Provided the stoker goes economically to work the prevention of smoke can be guaranteed by an appropriate method of firing. From this point of view also the principle finds justification of first securing economically favourable results, and then proceeding to aim at the avoidance of smoke.

What, then, are the conditions to which firing must conform in order to obtain a minimum of smoke in the combustion of fuel? It is still the predominant view that the prevention of smoke is best secured by a high temperature in the combustion chamber; or in other words, that the gases evolved shall be protected from cooling too rapidly at the heating surface of the boiler.

This view must now be qualified from our standpoint as incorrect. There are three principles to which we assign the

first place in firing with respect to smoke prevention. These are :—

(1) Admission of the necessary air mass for complete combustion in the proper proportions.

(2) Intimate and early admixture of the air with the gases.

(3) A sufficiently high temperature in the combustion chamber.

In the Society's boiler furnaces a sufficiently high temperature in the combustion chamber is always provided. It is not the premature cooling of the heating gases that leads to the development of smoke, but the momentary lack of air for combustion in the furnace. The reason why this shortage of air for combustion has not been recognised hitherto as the main factor in the development of smoke, lies in the circumstance that the conditions of combustion have in the majority of cases not been thoroughly investigated, and so the investigation has failed to determine the proper proportion to which the average surplus of air in combustion should be restricted so as to obtain the best economic results.

The provision of a duly apportioned air supply stands in no contradiction to the economic requirements of firing. It is not a question, for example, of diluting the smoke produced with air, but only of administering to the frequently varying requirements of air, which in most cases is only possible by admitting it not only from underneath but also from above the grate.

There is at first a strong objection to admit the possibility of a sufficient admission of air above the grate, particularly before the latter has been warmed. Many a man will shake his head at the simple experiment in firing of not quite closing the door of the furnace until the coal has discharged and burnt up the volatile gases contained in it, in order to give these gases the necessary oxygen. Yet experiments in waste gases teach us that this experiment of leaving the furnace door slightly open is well adapted to the prevention of smoke, as also to ensure economic consumption.

Air must be supplied above the grate in exact proportion as the fuel in question is rich in volatile ingredients. In firing with oil it is admitted that air must be introduced at that point where it most rapidly combines with the burning combustible. If we do the same with coal in respect of that part of it the combustion of which is analogous to that of oil—that is, its volatile constituents—we obtain the same favourable combustion free from smoke as we do with oil. Air must be admitted through the grate in order to consume the solid fuel that burns away upon the grate, and which is set glowing by the draught of air through the grate.

I have digressed a little from my real subject, but I am convinced that all attempts to prevent smoke will only meet with success when there is some uniformity in technical circles with regard to the ways and means for its suppression.

To those who would like to pursue this question further, I recommend the study of the works already mentioned, in which proof is given on the basis of practical examples of the correctness of our views.

It is our endeavour to place the measures for smoke prevention upon technical grounds. We do not wish to wait for the pressure of public opinion for the abolition of smoke, aroused by a general propaganda, but we wish to gain partisans for our views amongst our technical men themselves. We wish them to recognise that a smoking chimney must be considered as a symptom of a state of things that is capable of being improved. No employer of power can desire that his works should be recognised externally as being badly managed; he will therefore, in his own interests, endeavour to remove a defect so patently visible when smoke is developed, when he is convinced that there is a remedy which is in accordance with his economic interests. We look forward to a solution of the smoke question not through any repulsion on the part of Industry, but, on the contrary, through her help.

In this sense it affords us the greatest satisfaction that the interest and confidence of industrial men will be aroused by means of this exhibition, bringing before them as it does the work and the progress already achieved by the Society.

My wish is that a full meed of success may be the reward of the Coal Smoke Abatement Society's efforts in the face of its many difficulties.

SMOKE ABATEMENT IN CHICAGO.

By Thomas E. Donnelly

(President, Chicago Smoke Abatement Commission).

For the last four years the City of Chicago, through its department of Smoke Inspection, has waged a war against its smoke nuisance with renewed vigour, and under unusually favourable conditions. The ordinance itself has been comprehensive and authoritative; the appropriation of the Department has been many times greater than has ever before been appropriated by a municipality for this work; the *personnel* of the organisation has been intelligent, honest, and efficient; and what is most important, the work has been entirely free from hampering political influences.

The basis of the present Chicago ordinance was the work of the Secretary of the Treasury, who, as president of the Municipal Art League, obtained the passage of the first smoke ordinance in this country which recognised smoke prevention to be an engineering problem. Unfortunately, the ordinance failed to accomplish the results hoped for on account of administrative indifference and inefficiency.

The present reorganisation of the Department dates from 1907, when former Mayor Busse took office. A Committee of the City Club, which had been attempting to obtain a more rigid enforcement of the ordinance from the Smoke Department, called upon the new Mayor and requested his co-operation. As a result the Mayor called a conference of a few merchants, manufacturers, and engineers. After the matter had been thoroughly discussed, the Mayor finally said: "The people who make the smoke are the business men, and if anybody is going to suffer by a strict enforcement of the ordinance it will be they. If you can find me a number of these gentlemen in whom the public will have confidence, and who will undertake the responsibility of running the Department, I will turn it over to them." The Committee thus appointed, under the revision of the ordinance, was made the Smoke Abatement Commission. This Commission has general charge of the Department, dictates its policies, and has selected, through the courtesy of the Mayor, the Chief Smoke Inspector.

The *personnel* of the Commission consists of our leading retail merchant, three wholesale merchants, a steel manufacturer, an owner and manager of office buildings, and a printer—all business men—and each of whom operates one or more steam plants. No member has any political aspirations, and I am confident that there is no similar committee of citizens in Chicago whose members stand higher, both as business men and as public-minded citizens, than do my fellow commissioners. Though the recently-elected Mayor Harrison is of the opposite political party to the former Mayor, he has continued the Commission without change.

The ordinance declares the emission of dense smoke from any stack or chimney a nuisance, and requires the plans for all new or reconstructed furnaces to be presented to the Department, and unless these plans show adequate provision for the prevention of smoke, a permit is refused. For each violation of any of the prohibitions of the ordinance a fine may be assessed of not less than $10 nor more than $100.

The Department is organised on an engineering basis; the chief smoke inspector must be a mechanical engineer, qualified by technical training and experience in the theory and practice of the construction and operation of steam boilers and furnaces, and also in the theory and practice of smoke prevention. The same qualifications apply to the chief assistant. The deputy inspectors, of whom there are twelve, are practical operating engineers, with more than usual knowledge of the technical and practical problems of smoke abatement. The Department has in addition 22 observers, clerks, and stenographers.

The ordinance also provides for an advisory board of mechanical engineers, which is at present made up of two prominent consulting engineers and the managing engineer of a large manufacturing concern. The advisory board advises the Commission on questions of engineering policies, and also the Department upon unusual technical problems.

The Commission has adopted the policy that smoke abatement must be accomplished with the use in general practice of local Indiana and Illinois coals.

The procedure varies according to the problems involved. When an observer reports a violation, one of the deputy engineers is sent to the plant to make a complete survey of the conditions. He makes a report of the size and character of boilers, the number of square feet of grate surface, the size of the breaching, and all other facts which in any way apply to the problem of operating without making smoke. This report is carefully studied by the engineers of the Department, and they determine what changes in equipment or operation are necessary. The owner and engineer of the plant are then sent for and the situation is gone over in detail. If the smoke can be prevented by care in operation, the Smoke Inspector demands an

immediate clean-up, and enforces his demand by threatening suit. If necessary the Department even sends its own experts to show the fireman how to stoke properly.

If the cleaning up of the chimney involves alterations or reconstruction in the furnace and setting, these changes are insisted upon. When the owner shows a willingness to co-operate, he is given ample time to make the necessary changes. But when the owner refuses to accept the suggestions of the Department, and either by direct opposition or by delays attempts to avoid spending the money necessary to put his plant in proper condition, suit is started on each day's violation until he agrees to take the required action. After a plant has once been put in order violations which are not caused by accidents are prosecuted the same as if reconstruction work had not been done.

The plants in Chicago may be divided into five general classes, each class presenting its own peculiar problems of engineering and operation, and each demanding a different policy of administration. One class is known as stationary power plants, such as power plants of factories, office buildings, central power stations, and the like. Such plants, if the architect has done his duty in supplying ample boiler room and stack, and if the furnaces are properly designed and operated, present no insurmountable difficulties. Their great number—there are some fourteen thousand in the city—and the fact that each one has to be studied and negotiated with individually, really constitutes the problem. Yet, in spite of the limited force of the Department, a great number of plants of this class have been cleaned up, and when once they have been put in satisfactory condition they are held more strictly to the letter of the law than plants of other classes.

The railroads present an entirely different problem and a more difficult one, both from an engineering and operating standpoint. The limits of space in a locomotive and the great demand for power necessitate the burning of three or four times as much coal to each foot of grate surface as in stationary practice, and the same limitation of space prohibits the construction of tile-enclosed furnaces.

Most of the railroads have given the Department hearty cooperation—more, in fact, than any other class of plant owners. At the beginning of the work, at a luncheon with the railroad presidents, they agreed to try any suggestions which the Department might make as to apparatus, manner of operation, or fuel. The railroad work was put in charge of a deputy who had previously had railroad experience, and as a result of experiments conducted under his supervision the Chicago railroads have adopted a standard equipment. They have also experimented with coke and other such fuels without, however, very satisfactory results. The railroads themselves have supplemented the

work of the Department by 35 smoke inspectors of their own, who spend their entire time in looking out for smoking engines and showing the firemen *how* to fire properly. The crews caught violating are disciplined by the railroads themselves by demerits and lay-offs.

While the railroads have greatly reduced the amount of smoke made by their engines, the solution of completely eliminating railroad smoke is still an unsolved problem. Influenced by the example of the railroads entering New York City, there has been an insistent demand from the public that the Chicago railroads should also electrify their terminals, and there has been an equally insistent reply by the railroad officials that to electrify the Chicago terminals is an engineering impossibility, claiming that the problems of electrifying the Chicago district are entirely different from the problems that have already been solved in electrifying other terminals.

That the exact facts and engineering possibilities may be determined, and as the basis for subsequent negotiations, the railroads have agreed with the city to make an exhaustive study of all phases of the problem. This investigation is under the general charge of a committee composed of four representatives of the railroads, four representatives of the city, and seven representatives of the Association of Commerce. The actual work is under the charge of the chief engineer, Mr. Horace B. Burt, formerly President of the Union Pacific Railroad. Mr. Burt has associated with him a staff of the most eminent mechanical and electrical engineers of the country, supplemented with an office force of engineers and investigators. This work is expected to take several years, is costing about $150,000 per year, all of which is borne by the railroads, and when the report is finally finished, it will be the most exhaustive study of metropolitan terminals and their electrification ever made. Until the completion of the investigation the Smoke Department is holding the railroad up to the highest standards obtainable by means of careful operation.

The tugboats and vessels are classed together, and have given the Department much trouble. The Chicago harbour is entirely along the river, which runs through the very centre of the business section of our city. Tugboats and vessels' smoke in the very midst of the city has been a great nuisance. The marine boiler presents many of the engineering problems of the locomotive, and in marine practice there is not the same intelligent firing or excellent discipline as on the railroads. Vessel men are extremely conservative, and are sceptical of the engineering ability of any one not specialising on marine work, and for the first two years the Department received from them little help in developing better conditions. After attempting for two years to get the vessel men's co-operation in matters of stoking, changing of fuel, special automatic stokers, &c., the Chief Smoke Inspector

a year ago last winter notified all the vessel men that with the opening of navigation every violation of the ordinance would be followed by suit. After each of the companies had been fined upon several offences they began to burn a semi-smokeless coal from West Virginia, which heretofore they had claimed was impossible. As the coal used on the river was a foreign coal, this has inflicted little hardship upon the river interests. The tugs now use it entirely, and the vessels running into the city carry sufficient in separate bunkers to use while entering and leaving port. To-day Chicago River is about the cleanest portion of our entire city.

The special plants, such as box and furniture factories, iron works, and the like, all present many unusual engineering difficulties. The wood-working plant, which burns its shavings—sometimes alone and sometimes with coal—was a large problem. After three years of study and experimenting, to-day there is no wood-working plant in Chicago that need violate the ordinance. The annealing ovens for making malleable iron have given much trouble, but the engineers of the Department believe they now have this problem solved. Melting furnaces and terra-cotta kilns still baffle the engineers, and such violators are allowed to smoke with impunity, simply because the Department does not yet know what to order them to do.

Another class is that of domestic smoke. In Chicago there are thousands of two and three-storey apartment buildings heated from small furnaces burning bituminous coal. Since the anthracite coal strike the use of bituminous coal in private residences has also been greatly increased, and the smoke from these apartments and residences is fast becoming a considerable nuisance.

On account of lack of men the Department has paid little attention to this class of violators, giving its entire time to the more prominent ones. The question of domestic smoke, however, will eventually become the most serious problem in our cities.

In the present state of the art it is impossible to burn soft coal without making smoke in a small furnace which cannot be heated to high temperature, and a solution to this problem of domestic smoke must be solved by experimental work on the part of our engineers and scientists, perhaps by the use of the briquetting of coal, as in Continental Europe, or by the use of by-products coke, or some other treated fuel.

The question can be fairly asked, What has been accomplished in Chicago? We have not yet eliminated all the smoke from the city. Any stranger coming to Chicago will still find plenty of it, but in comparison with what it was the advance in smoke abatement is most gratifying. Unfortunately we have no means of scientifically comparing the present conditions with those of four years ago. The Smoke Inspector in his report published

the first of this year claimed that the smoke of the entire city had been reduced during his three years of office one-third. I believe his claim is too conservative. Of the 14,000 stationary plants in Chicago, about 3,000 of the most conspicuous offenders have been reconstructed. At the time of Mr. Burd's report, the smoke in the down-town district had been reduced 75 per cent., and on the railroads 50 per cent. During the present year, shown by comparative records, the smoke in the down-town district, has been reduced another third; and the railroads, under the spur of the investigation made by the Committee on Electrification, show the remarkable improvement of 77 per cent. over a year ago.

The results that can be accomplished are commensurate with the amount of money and men available to the Department. As there is little hope of larger appropriation from the limited funds of the city, it will be several years before the Department can say that every industrial plant in Chicago has been put in a position to be operated smokelessly; and even then there will be the need of constant vigilance to compel the owners to keep their fire-room practice up to concert pitch. But the Commission believes that the work is being carried on on correct lines; that the policies, even if aggressive, have been constructive and sane; that the confidence of the public and the plant owner has been won; that very substantial results have been obtained, and that each year will show a marked improvement.

The Chicago ordinance endows its smoke officers with two important powers: the power to pass upon the plans for all new plants, and the power to enforce the provisions of the ordinance by suit. Both are essential to accomplish results.

Under the ordinance the principal officers of the Chicago Smoke Department must be experienced engineers, because upon their engineering ability so much of the responsibility of the ultimate success falls. Theoretically, if in every new plant that is installed ample provision is made for the prevention of smoke, eventually we would have a smokeless city, as the old plants wear out and are renewed. It is, therefore, of the greatest importance that every new plant *does* amply provide for the prevention of smoke. While the principles of smoke prevention are well established, their practical application is a matter of great engineering nicety; and the engineers of the Department must be experienced and able enough to know just what design will be most effective for any particular condition, and arbitrarily refuse all bad or border-line proposals made by owner, consulting engineer, or the apparatus manufacturer.

The most difficult offender we have had to deal with is the one who had recently installed a new plant, and who, under incompetent or interested advice, put in what he supposed was a satisfactory smoke preventor, but which had proved a failure. The fact that he had spent money to take care of the smoke,

with at least the tacit approval of the former administration, seemed to him sufficient reason to be immune from prosecution.

The Chicago Department has assumed the authority to dictate to the plant owner what particular style of apparatus he should put in. As smokelessness is a combination of proper apparatus and careful operation, and as machinery is more certain than firemen, the Department has decided as far as possible to recommend only that apparatus which eliminated to the greatest extent the human element. In the Chicago district this calls for automatic stokers, and whenever conditions make them possible they are demanded ; and even other apparatus which, by careful operation, *could* be used without making smoke are refused. Where a stoker installation is not practical, the best type adapted is recommended, and the Department has not hestitated to recommend patent devices when, in their judgment, such devices were the best.

I realise that there are theoretical objections to putting so much arbitrary power in the hands of a city official. Chicago has provided against an abuse of this power by giving the plant owner the right to appeal to the Commission. On such engineering questions the Commission is advised by its advisory board of mechanical engineers, and while often the plant owner has felt that the department and Commission have been unnecessarily arbitrary, in every case the results have been a satisfactory plant, and the owner has generally become a staunch advocate of the crusade.

Without the power to compel plant owners to adopt its recommendations by fines, the engineering ability of the Department would have been wasted ; and without the same power to compel plant owners to properly operate their plants afterwards, the new or reconstructed plants would soon fall back into violators. I am convinced that any smoke ordinance that does not give its smoke officer this power will accomplish little in abating the nuisance. The Chicago Department does not use its power of bringing suit as a mere punishment for a violation, or for increasing the revenues of the city ; it brings suit to only compel a hostile or dilatory owner to do a specific act which the Department considers necessary to abate the smoke.

Unfortunately, a properly constructed plant does not always cease to be a violator, and the great majority of suits are brought to compel stricter attention to stoking. Occasional violations in plants in the outlying districts, especially if the plant has a good record, are often excused on a promise of more care in the future ; but the centre of the city, which includes the retail and wholesale districts, is subject to a much stricter policy. Within this district, which comprises about two square miles, every plant has now been inspected by the Department, and necessary changes have been made. Barring accidents, they should be operated without violating the ordinance, and what

is known as the 30-day rule has been applied. If a violation is discovered, the plant owner is allowed immunity, provided his excuse is a reasonable one ; but if he again violates within 30 days he is sued upon both violations. While the rule seems to many arbitrary, it has resulted in holding all the plants up to a very high standard of operation, and this rule will gradually be extended to the adjacent districts.

As an indication of the activities of the Department, and of how effective it believes this weapon of fines to be, during the year 1910 the Department brought 1,040 suits, and obtained a total in fines and costs of over $25,000. In one instance the fines from accumulated suits were $500, and in another $600. These drastic measures were necessary to compel the owners of these two plants to make the necessary changes. Yet, in spite of all these suits, the Department has never had a fine appealed.

Chicago has been fortunate in having had two chief smoke inspectors of peculiar fitness. Both Mr. Bird and Mr. Monnett are college graduates, with wide engineering experience, and to their strong personality is largely due the results accomplished by the Commission.

The message that the Chicago experience can bring to you is that smoke abatement is not primarily a matter of legislation, but of engineering and administration, and that with a capable head and sufficient organisation practical smoke abatement is a reasonable possibility.

The Smoke Problem in the United States of America.

By Z. A. Willard (Boston, U.S.A.)

The subject-matter in the United States of America covers an enormous extent of territory, from the Atlantic to the Pacific Oceans, 3,500 miles ; from the city of Mexico to the Canadian border, 3,000 miles ; and in this space every variety of smoke problem exists. Beginning on the Pacific coast :—The Southern Pacific Railroad owns most of the roads from New Orleans, Louisiana, to San Diego, on the Pacific ; from San Diego to San Francisco, and from San Francisco to Vancouver, and East to Ogden, Utau. This corporation, which owns or controls from 8,000 to 10,000 miles of railroad, burns oil on all its locomotives. This is cheaper than any other kind of fuel ; makes no smoke, no soot, no cinders. It costs but $500 (£100) to change over a coal-burning locomotive to oil. This road originally used English coal and coke ; later, coal found in Oregon. But the objection to solid fuel, in addition to smoke and dirt, was in the red-hot cinders thrown out of the stack. These cinders, falling on dry leaves and grass of the forests through which the railroads passed, occasioned fearfully destructive forest fires, destroying thousands of acres of timber, hundreds of ranches, houses, and sometimes whole towns. A few years ago, burning oil was discovered in Southern California. Wells were sunk and were so prolific of oil that the railroad felt justified in adopting it as a universal fuel, thus practically solving the smoke problem. All roads entering California use oil fuel.

The Mexican Central R.R. running from the American border to the city of Mexico, with its branches, uses oil exclusively as fuel, from 4,000 to 6,000 barrels being used daily. The reasons for its use are the same.

From the eastern slope of the Rocky Mountains to the western slope of the Alleghany Mountains, 1,500 miles by 1,000, railroads and all industries requiring power are forced to use bituminous coal. Practically, there is no other fuel. This coal is of low grade, cheap, and inexpressibly smoky. Huge areas are underlaid with this coal, which can be mined and delivered at the very low cost of about $2 per ton.

The smoke conditions in all this region are atrocious. In the great manufacturing cities, such as Pittsburg, Chicago, St. Louis, and Cleveland, the injury to health and property has been so great as to provoke public inquiry into the causes of

smoke and determination on the part of the authorities, aided by public opinion, to reduce and finally end the nuisance.. As an illustration of the damage done in Chicago in one year by smoke, it is estimated by the principal merchants of the city that in 1909 $40,000,000 (£8,000,000) would hardly cover the loss, and that not including damage to private property. The remedies for this evil already suggested are gas fuel derived from the coal, coke, or briquettes, and finally, electricity obtained cheaply from public plants. (See Report of Department of Smoke Inspection : City of Chicago, 1911.)

On both side of the Alleghany Mountains are vast bodies of coal. In Pennsylvania anthracite is the most common, a coal containing very little volatile matter and producing little or no smoke. Its domestic use in all the region east of the Alleghanies is almost universal, and the railroads running through the region use it largely or altogether ; but, unfortunately, the supply is limited, and according to experts it will not last 75 years at the present rate of consumption. There is, however, an almost unlimited supply of bituminous coal of much better quality than that of the coalfields of Illinois, &c., mentioned above. This coal is objectionably smoky, but is low-priced, and consequently is used almost entirely by railroads and manufactories on the Atlantic coast.

The use of this coal was the cause of one of the most frightful catastrophes in the history of railroading in the United States, by the collision of two passenger trains in the tunnel leading into the city of New York. The tunnel was so filled with smoke from the locomotives as to entirely obscure the signals, and two trains collided, with an awful loss of life. The Legislature of New York, in whose tunnel the catastrophe occurred, promptly passed a law forbidding the New York Central R.R. to allow smoke from engines within 20 miles of New York City, giving the road five years in which to equip all locomotives with electricity. All locomotives entering New York now are propelled by electricity (New York Central, New York, New Haven and Hartford, and the Pennsylvania). The Pennsylvania is electrified for 70 miles out from New York, the New York Central 30 miles, and the N.Y.N.H. and H. 50 miles. The law also forbids the production of smoke from all other industries.

In Boston there has been a constant fight for prevention of smoke, wherein the smoke producers have, up to 1910, had all the advantage. In 1901, the Massachusetts Legislature passed a law forbidding smoke from any source, but *exempting* locomotives. In 1902 this law was amended to exempt brick kilns in addition to locomotives. In 1905 it was further amended by exempting all public service corporations and wood-burning plants. In 1908 pottery kilns were added to the exemptions.

It will thus be seen that *all* the smoke producing plants were

exempt by law: the public left unprotected, and entirely at the mercy of the offenders.

The gross injustice of this law, and the injury to property and health by the consequent unrestricted smoke, caused a number of merchants, headed by Mr. Edward R. Warren, a prominent lawyer, to enter protest to the Legislature and to bring in Bills to abate the nuisance. In every case, however, the superior strength of the offenders politically and financially caused the Bills to be turned down and they failed to become laws. In 1907 an overflowing meeting of indignant citizens was held in the rooms of the Massachusetts R.R. Commission, through whose aid it was hoped to abate the nuisance. But the Commission was distinctly indifferent to the petitioners and decidedly favourable to the offenders, and nothing was done. It was then that a few of the sufferers began a campaign for Smoke Abatement, lasting from 1907 to 1911, with no help whatever from the Legislature and but little from their fellow citizens. Their plan was to make themselves acquainted with smoke conditions in all European countries and throughout the United States. The result was a mass of evidence showing the appalling injury to life and property from smoke, as well as the formidable loss to the smoke producers in the waste of fuel. It was definitely decided that so long as bituminous coal was used as fuel, the only relief from the smoke nuisance was in the education of the fireman, and that the management of a fire was as much a science as any other problem of chemistry. Armed with these facts, every smoke producing industry was interviewed in the friendliest manner; the facts were exhibited, and to-day Boston can boast of as little smoke annoyance as any city of its size in America.

In conclusion, I believe that liquid fuel is not used economically, but is as largely wasted in consumption as coal. When science has attacked the problem and solved it, oil will be the fuel of the future.

Should the Domestic Smoke Nuisance be any Longer Tolerated?

BY BAILIE W. B. SMITH

(Chairman, Air Purification Sub-Committee, Glasgow Corporation; and Acting President, Glasgow and West of Scotland Branch of the Smoke Abatement League).

IT is admitted that in Great Britain domestic smoke forms a large proportion of the pollution of the atmosphere. In the cities, towns, and villages where no industries involving the consumption of coal are carried on, the atmospheric pollution is practically all domestic smoke. Even in those places where coal is burned for industrial purposes, the domestic smoke forms a considerable proportion of the pollution.

In the City of Glasgow, in winter time, chemical analysis of the air shows that over three-fourths of the atmospheric impurities come from coal burned in the domestic fireplace or kitchener, including, of course, open fires and stoves used in shops, warehouses and offices, and therefore such fires are mainly responsible for any fogs that occur. And these fogs are more deadly because the products of combustion from domestic fires contain a much larger proportion of oily tars than are produced in most factory furnaces, where the coal is burned at higher temperatures.

In the winter of 1909 Glasgow experienced weather conditions that enabled us to demonstrate clearly the deadly effects of air pollution. By comparing its death rate with the rate of a group of other seven towns in Scotland, where the conditions of life are similar and where the temperature was the same, but where, owing to their geographical positions, they had not fog when Glasgow had it, we get an idea of the result of fog on the death rate; and if we select that group of diseases more directly caused or aggravated by bad air, we get an alarming result. On pages 63 and 64 are a table and diagram showing the death rates from "Bronchial Diseases"—bronchitis, pneumonia, and pleurisy—and when we consider that at least three-fourths of the smoke that caused the fogs that were responsible for these deaths were from domestic fires, we must conclude that the domestic smoke nuisance should be no longer tolerated.

Fortunately, to-day we are able to supersede the old-fashioned domestic coal fire by appliances which are smokeless, and all citizens should consider what they individually can do in their own houses and offices. The method available by the greatest number of the inhabitants to-day is undoubtedly the use of gas for heating and cooking purposes. In nearly every community there is a supply of gas laid through all the streets to almost all

the houses, and the improvements in the various appliances for using gas have been so great within the last few years that the objections which formerly could reasonably be urged against the use of gas have been removed.

About three years ago the Glasgow Corporation instructed

Deaths from Bronchial Diseases.

(Bronchitis, Pneumonia, Pleurisy)

1909-10	Glasgow		7 other Towns		Mean City tempr.	Weather Conditions
	Number	Rate	Number	Rate		
October (weekly average)	35	2·1	31	1·6	49·2	Clear to Dull
Week ending 6th Novr.	61	3·6	44	2·3	45·0	3 days Fog
" " 13th "	75	4·5	39	2·0	44·0	Dull, Slight Fog
" " 20th "	138	8·3	55	2·9	30·7	5 Days Dense Fog
" " 27th "	233	13·9	63	3·3	40·3	Hazy
" " 4th Decr.	171	10·2	93	4·8	42·3	Hazy or Wet
" " 11th "	198	11·8	76	4·0	37·0	4 Days Fog
" " 18th "	137	8·2	78	4·0	38·5	Slight Haze
" " 25th "	95	5·7	76	4·0	31·9	Slight Fog & Clear
" " 1st Jany.	93	5·6	88	4·6	43·1	Wet or Clear, 1 Day Fog

their chief chemist to make a research into the whole question of warming houses by gas, and, after about a year's work, he issued a most comprehensive and exhaustive report, which proved absolutely that gas-heated rooms are perfectly healthy and pleasant to live in. He demonstrated that the objection that used to be urged against gas fires, that they dried the air

of a room, did not hold good with modern forms of gas fires, which give out the heat by radiation alone, and not by convection, as in the earlier forms of gas fires or stoves; and that with these modern gas grates the humidity of the air in a room is

practically the same as it is in a room heated by a coal fire. His elaborate and delicate analyses of the air in rooms heated by gas fires showed that with properly constructed fires, such as are now universal, no trace whatever of impurity from combustion should get into the air of the room. Analysing the products of combustion that were carried up the chimney, he found that those from the coal fire, in addition to the soot and tarry matter, con-

tained about ten times more gaseous impurities than the products of combustion from the gas fire—the carbon-monoxide and sulphurous acid being about ten times as great from the coal fire as from the gas fire.

As regards cost, he found that with gas at 2s. per 1,000 cubic feet and coal at 10½d. per cwt., for warming a room during a whole day, gas was about 30 per cent. dearer than coal, without reckoning anything for the indirect expenses of labour, cleaning, &c., caused by the use of coal; but that for warming a room for a few hours at a time, such as morning or evening, the gas was not dearer than coal. If, however, we take into account all the incidental expenses connected with the use of coal—the labour and inconvenience involved in getting the coal into the cellar and from the cellar to the room, in getting rid of the ashes, and in cleaning the grates and flues and sweeping the chimney, together with the extra cleaning of the room itself and of the curtains and furniture, the difference in cost (if any) cannot amount to much. The convenience alone ought to compensate for any difference in cost.

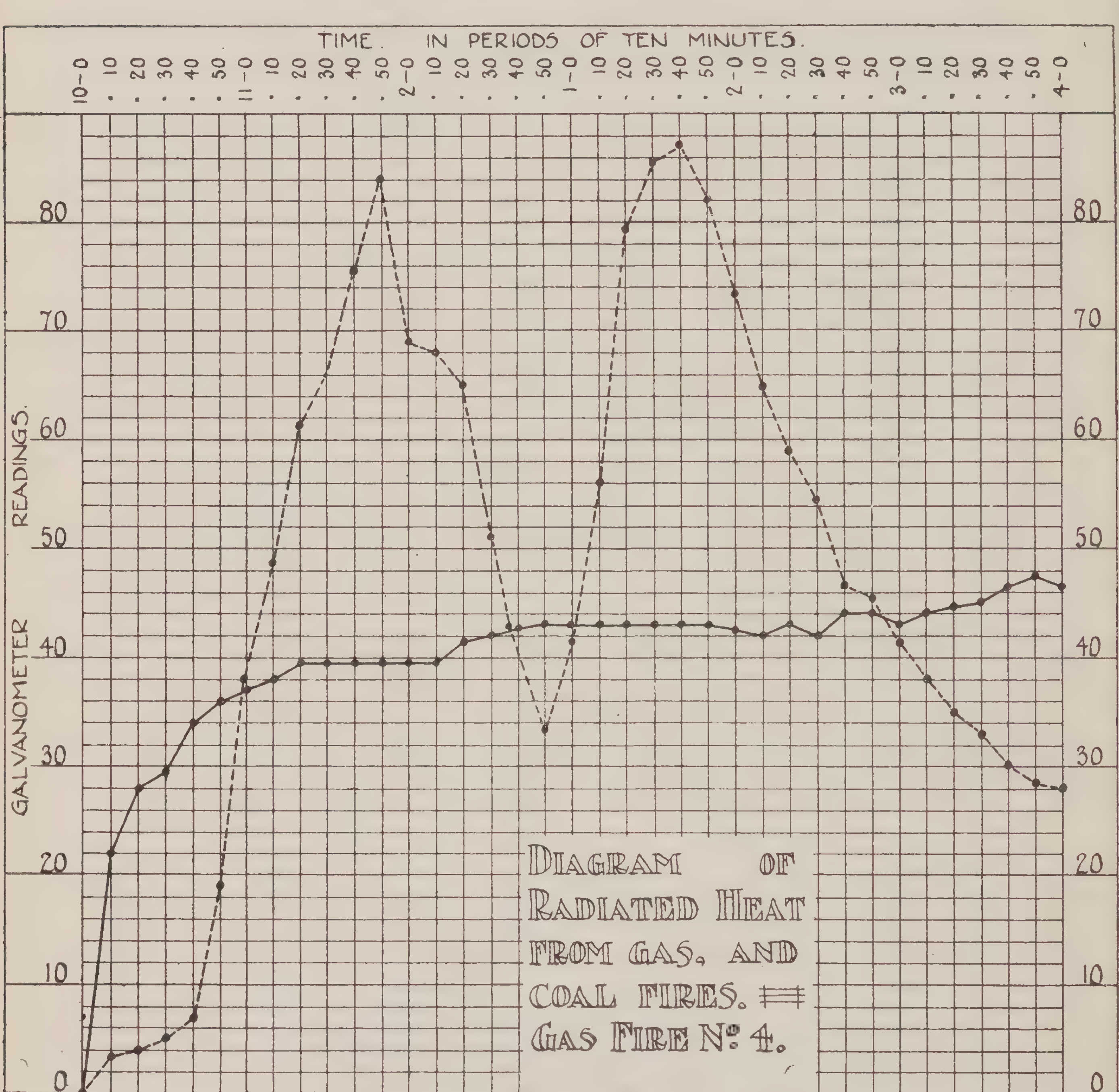
People who nowadays have their water supply led into their houses, and can get all they want by simply turning a tap, would consider it most inconvenient to have to draw their water from a well and carry it into the house. Why should they not be anxious to save the time and trouble connected with the use of coal when they can avoid it all, and light their fires by simply turning on a tap and applying a match?

Another great advantage of the use of gas is the complete control one has over the temperature of a room. It can be kept constantly at the same heat, or the temperature can be raised or lowered as desired. In a case of illness, this control is of the greatest advantage to the patient, any temperature desired being available during the day or night. Another point is the speed with which the temperature of a room can be raised. The diagram on page 66 shows how quickly the temperature of a room can be raised with a gas fire as compared with a coal fire, and how evenly the temperature is kept during the day by the gas but how erratic it is by the coal fire.

A further advantage of the use of a gas fire is that by it the ventilation of a room can be adjusted so as to change the air at a steady and constant rate without causing unnecessary draughts, as so often happens with the coal fire.

Therefore, to the use of gas I think we must look for immediate improvement, but the various gas undertakings, on their part, have still improvements to make, and I am surprised that at least some of them are not making the progress that one would expect. It is imperative that in the process of gas making they must produce a better form of coke than they have hitherto done—something that can be burned in an ordinary open grate as easily as coal can. Such a product, even if sold a little below

the price of coal, would fetch a higher price than the ordinary coke, and this increased price would go to reduce the price of gas, so that those who used gas would get it at a lower rate, and those who still preferred the open fire in the old-fashioned grate,



Bold line represents Gas Fire Readings.
Dotted line ,, Coal Fire Readings.

as well as those beyond a gas supply area, would get a smokeless fuel, and their inducement to use it would be its lower price as compared with coal. It seems strange that those controlling gas works are so slow to move in this direction. When we get

to this stage I think it is safe to predict that domestic smoke should be no longer tolerated.

Of course, electricity is the ideal heating force, and we are all looking to it to furnish a complete solution of the question in the future, but there is a good deal to be discovered about its application yet. Meantime cooking by electricity is quite practicable, and, with the appliances now in use, it is economical. It is also absolutely clean. The apparatus can be placed in any position convenient to use ; in fact, the dinner can be cooked on the dining table, if desired ; but for warming a room it is still too expensive for most people, and only comparatively few houses are wired for electricity. While we are waiting for the more universal adoption of electricity we can meantime rely on gas for all our domestic requirements.

One hindrance to the use of gas and electricity must be immediately removed, and that is the unfair and financially unsound method that many Corporations have of penalising the users of gas and electricity by taking large sums from the annual revenue of these departments and devoting them to what they call *relieving the rates*. Many towns take such sums from their gsa undertakings as necessitates charging the gas 2d. or 3d. per 1,000 cubic feet more than it should be.

This method of contributing to the rates does not, in reality, lower the rates, but only alters the incidence of taxation ; it means that the householder who has fitted his house with gas appliances, and thus kept the atmosphere pure, is compelled to pay more in rates, whereas his next-door neighbour, who, by continuing to burn raw coal in the old-fashioned way, really pays less in rates while he is helping to poison the atmosphere for himself and the community. Unfortunately, this contribution is levied by many English local authorities, but I am glad to say that the Corporation of Glasgow, during the forty-five years that they have owned the gas works, have not adopted that policy. The Consolidated Gas Act we got two years ago does not allow us to do it, and I hope that the Government will see that this power is withheld from local authorities wherever possible, as it is a hindrance to progress.

Notes on Recent Progress in the Campaign against Black Smoke in the United Kingdom.

By John B. C. Kershaw, F.I.C., F.S.S.

The author proposes to review briefly the evidence that the campaign against smoke in the United Kingdom is at last beginning to produce practical results, as regards the diminution of both domestic and factory smoke, and the increase of popular interest in the subject. The facts and figures given should prove a stimulus to all who are working for the solution of the smoke problem, and encourage them to further efforts in the cause of smoke abatement.

Meteorological Data.

The most direct proof that the soot and dirt suspended in our atmosphere is diminishing rather than increasing, is to be found in the figures relating to the duration of fog and sun shine in London, in the 1910 Report of the Coal Smoke Abatement Society. These represent the annual averages for three successive periods of nine years each, and are as follows :—

Period		Days with Fog.		Hours of Bright Sunshine
1883–4 to 1891–2	......	29·9	......	55·6
1892–3 to 1900-1	......	20·7	......	70·1
1901–2 to 1909–10	......	10·6	......	93·5

The reduction in the days with fog, and the increase in hours of sunshine, is very striking. In order to supplement these returns, which apply only to the winter months, the author has obtained from Dr. Norman Shaw, Director of the Meteorological Office, the detailed figures for the observations made at Westminster during the period 1902-1911.

Year.		No. of Hours of Sunshine.			No. of Days of Fog.	
1902	......	1,010	average, 1,257	......	39	average 27½
1903	......	1,182		......	16	
1904	......	1,290		......	44	
1905	......	1,290		......	23	
1906	......	1,513		......	16	
1907	......	1,235	average, 1,341	......	37	average 17
1908	......	1,365		......	15	
1909	......	1,371		......	12	
1910	......	1,144		......	4	
1911	......	1,592		......	*—	

* The extended observations at Westminster ceased with the removal of the Meteorological Office to South Kensington.

When studying comparative statistics of this kind, it must be remembered that the population of the London area, and also the amount of fuel burned in that area, is increasing, and that as a consequence, had no improvement occurred in the methods of using solid fuel for domestic or industrial purposes, we might have expected the sunshine records for the period covered by the above table to show a distinct tendency downwards. The increase in the hours of sunshine is perhaps not so noticeable as the reduction in the days of fog, but if one compares the average number of hours of sunshine for the first and second halves of the period (each containing one record year, 1906 and 1911), a yearly average is obtained for the first half (1902-1906) of 1,257 *hours*, as compared with 1,341 *hours* for the second. This is a distinct improvement, since it represents an increase of 84 hours of sunlight per year, in face of the growing population and increased consumption of fuel. The corresponding averages for fog are much more striking; and since Dr. Norman Shaw has stated that 20 per cent. of the fogs in London are wholly due to smoke, these records are a proof that London's atmosphere is becoming less opaque, and that the improvement is going on year by year.

What is happening in London is taking place also in each crowded centre of population and industry in the country, and though the improvement may not be so rapid as some of us desire, it exists, and is of hopeful augury for the future.

Direct methods of measuring the soot and dust suspended in the atmosphere have been employed recently in Leeds, Glasgow and London, and records of the results obtained have been published in interesting papers by Professor Cohen for Leeds, by Inspector Fyfe for Glasgow, and by Dr. Owens and Dr. Des Voeux for London. As the methods and apparatus used were different in each case, the figures obtained are useless for comparative purposes. When a standard method of making these observations has been decided upon, it will be possible to obtain proof that our city atmospheres are improving, alternative to that provided by the sunshine and fog records for particular localities.

Educational Work.

The increased attention now given by public authorities and voluntary societies to smoke abatement, is perhaps most strikingly reflected in the extension of educational work, and this is the most useful and hopeful line of attack upon the smoke evil.

The classes for stokers, promoted by the Coal Smoke Abatement Society, and started at the London Borough Polytechnic in the winter of 1906-1907, have been followed by similar lectures in Glasgow, Liverpool, Manchester, and other centres of manufacturing industry; while the Exhibition of Smoke

Abatement Appliances and the Conference, held in London in 1905, have been followed by similar exhibitions and conferences in Sheffield (1909), Glasgow (1910), and Manchester (1911) The spread of information upon both the theoretical and practical sides of smoke abatement, which has resulted from these lectures, exhibitions and conferences, cannot fail to have good effect in familiarising all who use solid fuel with the scientific principles which underlie its combustion without smoke. In Glasgow, where the greatest success has been achieved in this educational work, the Exhibition of 1910 remained open three weeks, and attracted an average attendance of 4,000 per day, while the two courses of evening lectures arranged for the winter months of 1910-11 (as a sequal to this exhibition), were also remarkably well attended.

These lectures for the general public covered such subjects as "The Black Smoke Problem," "The Necessity for Pure Air," "The Chemistry of Combustion," &c., &c., and were delivered in the large hall of the Technical School by experts connected with the Health and Medical Departments of the University or city. The lectures for stokers were delivered in five different centres of the working-class portion of the city by the five city smoke inspectors, and attracted an attendance of 186. In the majority of cases the employers paid the fee of 5s., and urged the men to attend regularly. Chief Sanitary Inspector Fyfe reports that the classes for stokers and lectures to the general public have been continued during the past winter with encouraging results, although naturally the attendance has not been quite so good as during the first winter, when the classes and lectures were a new thing. The total number of firemen enrolled at all the classes during the past winter has been 135, and the average attendance at the lectures has been between 200 and 300, the number attending any particular lecture being greatly influenced by the district in which it is given. The last lecture in the Southern District of the city attracted an attendance of 900, and the Hall could not accommodate all who wished to get in.

As regards the London Lectures, these are still continued at the London Borough Polytechnic, but were most successful in the early years, when attendances of 89 and 90 were obtained. My friend Mr. Wm. H. Booth, who conducted the class for the first two seasons (1906-07 and 1909-10) writes that the men turned up well at them, and they had very pleasant evenings together.

In Liverpool the lectures for stokers were started in the winter of 1910-1911 on similar lines to those of Glasgow, under the auspices of the Sanitary Science Committee of the Corporation and of the Engineering Department of the University, and have been continued during the present winter. An attendance of 65 men was obtained for the first winter's class, and of 35

for the second. It must be noted, however, in comparing these attendances with those recorded in Glasgow, that this class is hampered by being held at the University, which is far removed from the quarters of the city where the labouring classes and ship-stokers reside, and that the attendance is confined chiefly to foremen and engineers. The writer has had the pleasure of delivering two of the lectures to this class each winter, and can vouch for the interest which the majority of the men show in the subject. Visits to works possessing modern and efficient boiler plant have also been arranged by Smoke Inspector Macaulay, who with the writer has shared the brunt of the work, and these visits have proved most useful in driving home by practical example the teaching given in the class.

In Manchester two courses of lectures for stokers and boiler engineers on "Boiler Management and the Prevention or Abatement of Smoke" have been carried on at the Municipal School of Technology. For the winter class an attendance of between 32 and 39 has been obtained, and Mr. James T. Hodgson, the lecturer, reports that the diligence and attendance of the students has been most encouraging. A fee of 2s. 6d. was charged for this series of lectures, and certificates of merit are to be issued to those who pass the examination which is to be held at its close.

This educational work amongst stokers and engineers should prove of great value in fighting the smoke evil, and it is to be hoped that one result of this conference will be a wide extension of educational work on these lines amongst stokers in other centres of manufacturing industry.

Voluntary Agencies.

The Coal Smoke Abatement Society, which was founded in the year 1899, and has its headquarters in London, has continued its crusade against the smoke evil with increased vigour during the past few years. The very successful exhibition of Smoke Abatement Appliances and the conferences held in London in December, 1905, was promoted by this Society in conjunction with the Royal Sanitary Institute, and the classes for stokers at the Borough Polytechnic in London were also arranged and financed by this Society. Its latest work in the cause of smoke abatement is the promotion, under the able management of Mr. Frederick W. Bridges, of the Exhibition and Conference which we are attending to-day!

The following extracts from the 1910 report of the Society will indicate the progress and limitations of its work :—

"Within the area known as Greater London there are no fewer than 35,000 factories and workshops. When the Society commenced its operations, it may safely be said that the large majority of those premises more or less frequently emitted black smoke. Now, only a small minority offend, for most

manufacturers have learned that, to their own pecuniary advantage, they can carry on their work without causing smoke nuisances. The effect of the Society's system of inspection is really striking. Observations are made in a district, and in a short time the Society's reports generally lead to the temporary cessation of nuisances. When that object has been achieved, and the inspector is transferred to some other district, it almost invariably follows that complaints begin to arrive of a fresh outbreak of smoke on the part of the old offenders, an outbreak which does not cease until further reports are made, when the same process is repeated."

"During the year 1910 the number of cases of smoke pollution observed by the Society's inspector, and considered by the Committee, amounted to 1,094. As a rule, where the observation disclosed an obvious nuisance, a complaint was made by the Society to the Borough Council or other local authority concerned. But in a considerable number of instances, where it seemed reasonable to conclude that the smoke nuisance detected was the result of an accident or temporary breakdown, the firm affected was written to by the Society, and no formal complaint was lodged with the sanitary authority. Action of this kind is always appreciated by manufacturers, and where there has in the past been an absence of smoke from their Works, the Society invariably writes a friendly letter so as to give no ground for any possible assertion that it acts harshly and without consideration for those unforeseen difficulties, which are sometimes experienced even in well-equipped works."

"On the whole, Borough Councils may be said to discharge their obligations to the public in suppressing smoke nuisances. The inaction of a few of such bodies, such as the Southwark Borough Council, stands out in unpleasant relief."

"It is only by incessant vigilance and effort that the smoke evil can be successfully encountered, and the Society appeals for funds to enable it to continue its work on the lines of that of the past twelve years. The Committee feels that the Society's efforts deserve greater support than has hitherto been bestowed upon them. With an income of only £200 per annum, much has admittedly been accomplished by the Society. It has been shown that smoke abatement is no idle dream; that, without harshness to manufacturers, local authorities can deal satisfactorily with a great deal of factory smoke; that, indeed, the manufacturer can in almost all cases effect striking economy in his working expenses by using the means which modern research has rendered possible for securing the maximum advantage from bituminous coal; and finally, that the private householder, by using smokeless methods of heating and cooking, can contribute his share to the cleansing of the atmosphere. But much remains to be done before the idea of the practicability of a pure air can be spread broadcast in the minds of the

public, and the Society appeals for a generous extension of the financial support hitherto accorded to its efforts.''

Engineers and chemists engaged in the practical attempts to secure the smokeless combustion of fuel are specially invited to join this Society.

The Smoke Abatement League of Great Britain is another active society, which is doing good work. Promoted by Principal Graham, of Manchester, and a few friends, as a result of the Conference of Representatives of Local Authorities and Societies at the Sheffield Exhibition of 1909, the League's objects as set forth by its Secretary, Mr. E. D. Simon, are :—

(1) To ed cate public opinion as to the urgency and practicability of smoke abatement.

(2) To endeavour in all ways to increase the consumption of gas and electricity for power, heating, and cooking.

(3) To stimulate the activities of local authorities with regard to factory chimneys by the employment of private smoke inspectors.

(4) To forward any reforms of legislation that are likely to render the efforts of local authorities more effective.

Three branches of the League have been formed at Glasgow, Manchester, and Sheffield ; and of these, the Glasgow and West of Scotland Branch has been the most active and successful. The lecture courses for firemen and for the general public in Glasgow, already alluded to, were promoted by this branch of the League, while the Manchester branch organised the successful Exhibition and Conference held in that city in November, 1911.

The time and energy of the League's officers for the coming year is to be devoted chiefly to pushing forward the suggested legislation on smoke abatement.

The following details of the conditions of membership of the League are taken from the report of the Manchester conference:—

"Municipalities can become affiliated to the Smoke Abatement League upon payment of an affiliation fee of one guinea. This sum entitle sthe affiliated branch to receive any publications which the League may make during the year, as well as to appoint two members to the Council of the League, and so exercise a share in its management.

"The League is also anxious to enroll as members as many persons as possible who are interested in smoke abatement. The minimum annual subscription for individuals is 2s. 6d. This makes the subscriber a member of the League, and entitles him to receive all its publications.''

Conclusions.

This brief summary of the work that is being done in the United Kingdom, in connection with the Smoke Abatement Movement, would be incomplete without some reference to the direct evidence, that both in the domestic and industrial field

of use, more scientific methods of generating heat and power are advancing in popular favour. To show how rapidly gas is displacing solid fuel for cooking and heating purposes, figures taken from the "Gas World Year Book," showing the increase in the total number of gas cookers in use in the United Kingdom during the period 1902-1912, may be given.

The totals are: For 1902, 998,878; and for 1912, 2,921,299—an increase of 1,922,421 in the ten years. This huge total, it must be noted, does not include gas fires. The correctness of these figures is supported by the total given in the 1910 Report of the Coal Smoke Abatement Society, for the gas heating and cooking appliances installed by the principal London Gas Companies. This total was 1,300,000.

Other large towns can, of course, show a similar extension of the movement to utilise gas for heating and cooking purposes, while the electric light and power companies could provide evidence that electric power is displacing the small power generating plants, which at one time were a common feature in large towns and centres of manufacturing industry.

The most striking evidence that the educational work of the Coal Smoke Abatement Society and its supporters during the past ten years has not been wasted is perhaps to be found in two papers read before the Manchester Smoke Abatement Conference in November, 1911. It has often been urged against smoke reformers that they are cranks and visionaries, with no practical knowledge of the conditions of manufacture or of works economy, and that their claims for the smokeless combustion of fuel for industrial purposes are impracticable and foolish. At Manchester, two engineers, Mr. G. B. Storie, M.I.M.E., of Rochdale, and Mr. James Bibby, M.Sc., of Liverpool, both in charge of large power plants, contributed papers, which proved beyond the shadow of doubt that cheap bituminous coal could be used in a well-designed and well-managed boiler installation, without causing any smoke nuisances, and that steam could be generated most economically under such conditions of work. The papers are to be found in the Report of the Conference.

Another fact of importance in its bearing upon the Smoke Abatement movement is that as a result of a correspondence upon Sheffield's smoke problem, carried on in the *Sheffield Daily Telegraph* in January of the present year, the steel manufacturers have appointed a committee to investigate the possibilities of gas and electrically-heated furnaces, as substitutes for the smoke-producing reheating furnaces of that city.

With facts like these on our side, we can continue our educational propaganda in favour of smoke abatement in a hopeful spirit, for they prove that we have at last impressed the public with the importance of the question, and with the practica possibilities of burning fuel without smoke.

In conclusion, the writer would draw attention to the fact that although bituminous fuel can be utilised now for all industrial purposes without the production of any smoke, by aid of well-known appliances and methods of work, it by no means follows that changes will not be introduced into the methods of employing this type of fuel for heating and steam-raising purposes in the near future. The writer is convinced that the gas engine and oil engine will gradually supplant the steam engine as a prime mover, and with this change the burning of bituminous fuel under steam boilers will give place to its utilisation in gas-producing plant. Gas-fired boilers and furnaces will also take the place of those now heated by solid fuel, and in this new development Bone's system of surface or flameless combustion will play a leading rôle. The next ten or twenty years are therefore likely to witness some striking changes in the use of fuel for manufacturing purposes, all tending to diminish factory smoke and to bring cleaner skies and more sunshine to those who dwell in our great centres of manufacturing industry.

Smoke Abatement from the Inspector's Point of View.

By W. Nicholson
(Chief Smoke Inspector, Sheffield).

The purpose of this paper is to show that the prevention of coal smoke is both practicable and profitable.

Coal Consumption.

In 1910 the coal production of the principal countries was, in the United Kingdom, 264,433,000 tons; Germany, 150,372,000; France, 37,254,000; Belgium, 23,532,000; and the United States 447,837,000. The aggregate was over 800,000,000 tons, an increase of 42,000,000 tons on the output of 1909. The total known coal production of the world, exclusive of brown coal, or lignite, in 1910 was about 1,035,000,000 tons. In the United Kingdom probably one-third of the coal is wasted, owing to the absence of a sensible and scientific system of combustion. As it is questionable whether other countries do any better, a waste of 333,000,000 tons yearly takes place.

The Smoke Nuisance.

A nuisance, in common law, is anything that causes personal discomfort, injury to public or private property, or injury to health. The smoke nuisance is all three.

Smoke is responsible for 25 per cent. of the thick, dirty, pungent, fatal fogs, shuts out 50 per cent. of sunlight, and turns day almost into night. It consists of solid, sticky, tarry, oily, and gaseous matter, and disfigures and destroys nearly everything it falls upon. A recent investigation of London's soot-fall showed the annual amount to be not less than 76,050 tons. This included ammonia 6,000 tons, sulphates 8,000, chlorine or chloride 3,000 tons, the remaining 59,000 tons consistng of tar, carbon, &c.

The cost in coal, wholesale destruction of public and private property is too great for tabulation, but the cost in health is much greater, for the lungs quickly change from pink to the colour of coal, producing physical degeneracy and various disorders and diseases. In the fourteenth century John Smith was hanged for creating a smoke nuisance; in the twentieth century people are sometimes punished for river pollution, for adulteration of food, but for poisoning the air which everybody must breathe they are merely punished with a caution.

Practical Smoke Prevention.

Practical smoke prevention means the prevention of every particle of smoke not necessary for the working of boilers, furnaces, or fireplaces, not to obstruct or interfere with legitimate

trade or processes. It is the utilisation of the best known means and methods of preventing the formation or discharge of smoke, and the application of the best known methods of utilising the waste gases.

Sheffield in 1890 was called " a suburb of Hell." There were over 1,000 chimneys serving boilers and furnaces, and over 3,000 serving almost every type of furnace, pouring out day and night dense volumes of black smoke up to 40 minutes in the hour. It dawned upon the minds of a few public-spirited citizens that more smoke was made than was necessary, and that the smoke abatement law which had been in existence fifteen years ought to be administered. They were marked men, but they kept pegging away, in private, in the press, and on the platform, until their importunity prevailed. The Corporation appointed a smoke inspector who visited the works, dealing with the biggest sinners first. Their anger was very soon over, and they acted most reasonably when informed that the Corporation wished to co-operate with them, to help, and not to hinder. Some spent thousands of pounds on new devices when they realised that prevention of smoke would be profitable. The stokers were much more difficult to deal with, and resented interference. They believed the more smoke the more steam, and it was no easy task to convert them. They were instructed in side firing alternately, lightly, more frequently, admitting into the furnace the necessary quantity of air to prevent the formation of smoke, and the result was—no dense smoke emitted from the chimney, more steam generated, and less coal consumed. It was a surprise to the stoker, and money in the pocket of the master, who was so satisfied that he raised the wages of his men. Having demonstrated the non-necessity (under normal conditions) for black smoke from boilers, the Corporation fixed the following working limits :—For one boiler 2 minutes of black smoke was allowed in the hour ; 2 boilers 3 minutes ; 3 boilers, 4 minutes ; 4 and more boilers, 6 minutes ; and if a chimney served 1 boiler and the furnace or more, 6 inutes were allowed in the hour. If the limits were exceeded, the excesses were considered a preventable nuisance within the meaning of the Public Health Act, 1875. A Statutory Abatement Notice was served, and if the limit was again exceeded police court proceedings were taken, a magistrate's order made to abate the nuisance, and penalties from 5s. to £5 were imposed. In less than 10 years there was a most marked improvement in the atmospheric conditions ; boiler chimneys had ceased in general to emit over 40 minutes of black smoke in the hour, for the 8,000 hourly observations yearly on the worst offenders only averaged 2·2 minutes per hour.

In 1907 Sheffield had 1,428 hours' sunshine, deserving no longer the name of the city of Smoke. She had more sunshine that year than any other large city or town from the North of

Scotland to the South of England, the average excess being 273 hours. There is nothing miraculous in the transformation of smoky Sheffield. It has been done by the adoption of a common sense and scientific system of feeding the fires.

Furnace Smoke.

Metallurgical furnace smoke is as much inside the Act as boiler smoke. For the Public Health Act, 1875, says, "That all furnaces and fireplaces (except the domestic grate) must as far as practicable consume all the combustibles used therein." Furnace smoke, like boiler smoke, is only exempt up to the point of practicability. Some metallurgical experts, however, say they must have an unlimited amount of smoke, for it is part of the process of steel making. British steel metallurgists were supreme in 1870. To-day we produce 7,000,000 tons per year; Germany 14,000,000; and America 20,000,000. It is asserted that best steel requires the burning of 200 per cent. more coal per ton of steel than is required in working a softer or inferior steel. But how much is the necessary amount of smoke? Surely the metallurgist can fix it to 10 or 20 minutes in the hour. If A can and does produce the finest and best class of steel, and emits less than 6 minutes of smoke in the hour, why should B be allowed to make in the hour 26 minutes, or more, simply because he says he cannot help it? To punish him for doing so would not damage the steel, but benefit him, and everybody else. It has been the universal custom to erect very low chimneys to serve furnaces, about 25 ft., instead of 125 ft. and a separate chimney for each furnace, because it is contended that the draught can be better regulated by a separate low chimney than a tall one. But hundreds of furnaces are being served by chimneys 150 ft. high, one chimney serving 6 and more boilers and as many furnaces, and there is not the slightest difficulty in regulating the draught by the damper, while the work is more cheaply done. But the chief objection to tall chimneys serving a number of furnaces is the initial cost.

In furnaces where the normal temperature is above gas ignition point there is little difficulty in preventing (with a profit) 70 or 80 per cent. of the smoke made. Many of the high-temperature furnaces are successfully worked by gas and electricity, the steel being either melted or reheated for forging, pressing, or rolling. But similar satisfactory results are being obtained from coal-fired furnaces, with a sensible system of stoking. A chimney 140 ft. high served one boiler and 9 large high-temperature reheating furnaces. In one hour the chimney emitted 50 minutes of black smoke, the chimney-top was hardly ever clear. The managing director said "It was from the furnaces, and could not be prevented without injury to the steel." However, these men were made responsible for firing the furnaces, they were instructed how to fire, putting about one-fourth of

the amount of fuel on the fire at each firing as had been done previously, admitting into the furnaces the necessary amount of air for complete combustion, and instead of making 50 minutes of black smoke each hour, they did not make 5. The steel was, too, heated more quickly. The firm were so satisfied with the result of the demonstration that they have continued to stoke their furnaces scientifically with special stokers, and in no instance has the chimney in 30 hourly observations exceeded 6 minutes of black smoke in the hour. This is only one example of many, proving the non-necessity of excessive smoke from high-temperature furnaces. But in furnaces worked at a low temperature, for annealing and reheating the best and very thin steel, the prevention of the formation of smoke is impossible, in fact the steel requires the smoke envelope, for oxidation would spoil it. Some successfully anneal steel with gas, others with coke. Those who persist in the old system of annealing with coal-fired furnaces need not emit the smoke at a low level after it has done its work in the furnace, for it can be passed through waste heat boilers, and utilised, and the gases discharged from tall chimneys which will considerably reduce the nuisance.

It is the duty of local authorities, in the abatement of smoke from furnaces, to pursue a similar practical policy which some local authorities have pursued for a long time *re* boiler smoke. The expert officers ought to spend the necessary time in the works and find out how much smoke is really necessary for working efficiently the various types of furnaces, suggesting the most up-to-date methods, and should these not be adopted then the alternative would be prosecution, and the court would convict. No one could reasonably protest against such procedure. It would not cripple or ruin trade, but enormously reduce furnace smoke, and the smoke maker would ultimately bless, instead of curse, the local authority.

Domestic Smoke.

Most people will now agree that it is practicable to do the work of the domestic fire with less smoke. But the nuisance is exempted by the Public Health Act, 1875. The real reason for statutory desertion is that domestic fires were not considered sinners. In Dresden as far back as 1887, a by-law was enacted dealing drastically with industrial premises, which also extended to private premises, providing that "in private dwelling houses the heating arrangement must be so contrived as to produce as little smoke as possible." Why should our domestic fires be allowed to create an unnecessary nuisance any more than any other fireplace or furnace? Though not possessing statutory power, much has been done to lessen the nuisance. Modern grates when compared with their predecessors burn less coal, give out more heat into the room, make less smoke, render houses more habitable, and produce a greater demand for tenants.

Administration.

About 10 per cent. of local authorities in the United Kingdom administer the smoke law in its letter and spirit, and in 20 towns policemen play a prominent part in the administration of smoke law. Not more, however, than 25 authorities have special smoke inspectors. Some authorities authorise the sanitary inspector to make a few observations, which he does, reports the results, and if the chimneys observed scarcely cease smoking, after many cautions and threats proceedings are taken, and often fail, because the sanitary inspector is not an expert in the prevention of smoke. But upwards of 80 per cent. of the local authorities do absolutely nothing toward ridding the country of the smoke plague. Many no doubt are conscientious objectors to any interference with the smoke, believing it represents money.

Government Action.

Seventeen years ago I wrote to the Local Government Board suggesting the creation of a "Smoke Department"; the reply was that "the suggestions had been placed on record for consideration, in the event Parliament decided to take action on the smoke question." The Local Government Board are the guardians of the public health, and it would be no innovation to create a "Smoke Department" to help the health authorities. It is not suggested for a moment that the Department should supersede the local authority, but supervise, advise, and co-operate, and I know they would warmly welcome such Government help.

If a Smoke Department were created, and a few inspectors appointed, they would render invaluable service to the nation. The German Government in 1902 voted £4,000 for smoke abatement lectures, and the salaries of officials to visit works, co-operate with masters, and instruct firemen how to fire smokelessly and economically. We may agree or disagree with Germany in tariffs, or such trifles, but all of us, I am sure, agree with the Government in their practical smoke prevention policy. In the different States of America the Government is moving in the right direction, for they have made the Smoke Department one of the principal departments. In 1906 the Government of India created a Smoke Department in Calcutta. Two engineers were appointed as inspectors, and instructed in administrative work, and the report of 1910 is proof of the good being done.

A managing director of a large engineering firm in Calcutta said to me, "Why doesn't the Government start in England first, yes, in London, which is worse than Calcutta?" The answer is that the Government will take action when the people demand it. If general and practical action were taken, I am convinced that in a very short time much of the smoke pall would disappear.

Smoke Abatement in Pittsburgh.

By Dr. R. C. Benner, Ph.D.
(University of Pittsburgh.)

Smoke, finally, has forced itself upon our attention.

The world at large has not, up to the past few years, regarded it as a waste. It has been considered synonymous with prosperity. Its right to cloud the heavens has been traditional.

But now it is seen that in itself it is a question of dollars and cents, this smoke proposition. It lays its heavy tax, directly or indirectly, upon everything we eat or wear and the houses in which we live. It is just another of the factors in the excessive cost of living and an exceedingly important one.

Smoke exists and has existed in every great city of the world where soft coal is burned. The manner in which the problem is attacked in the big metropolitan centres affords an interesting and profitable subject for study. The wise business man everywhere has been studying the problem and reaching the same conclusions, and therefore the results are of interests and value, not only for one time and one place, but for other times and places as well. Everywhere there are practically similar conditions to be overcome, and the movement is gaining headway and gathering aggressive support all over this country as well as abroad, for the need of some amelioration of this general nuisance becomes more imperative each day.

Strange to relate, when one stops to consider the breadth of interest and importance of this problem—together with the fact that so many thousands have worked on its various phases, and that so much has been written, and is being written on the subject —still no co-ordinated effort of one group of men has been made to undertake a scientific study of the problem as a whole. This is our aim at the University of Pittsburgh.

In the work which we have already undertaken on this broad subject, there has been forcibly impressed upon my attention the general quiescent attitude and ignorance of the people at large concerning the real enormity of the evil and even of its existence as such. Therefore, I feel the need of making of this problem a scientific study, that there may be placed before the public evidences of smoke's harmful existence, in a manner as nearly as possible irrefutable. The study is being pursued in the broadest conceivable manner from all standpoints, that, by the co-operative effort of a group of researches we may conduct a more thorough investigation of this subject than has ever before been made.

Inquiry is being instituted, in the most accurate manner possible, into the true increase in the cost of living due to the damage done by smoke to the property of the residents of this smoky district. And, aside from the residents and manufacturers themselves, in the list of sufferers in this connection may be included dwellings, hotels, hospitals, picture galleries, museums, offices, banks, libraries, and stores, both wholesale and retail, &c. Special stress will be laid upon this portion of the investigation, because of the number of component parts and the manner in which they are interwoven with the work of the other divisions. Too, this will be one of our most powerful means of bringing pressure to bear as a means of securing proper legislation. It is therefore receiving careful thought and attention.

The mechanical engineering side of the question is in general so well in hand, and has had so much time and money spent on its consideration, that all we feel it worth while to undertake from this point of view is a mechanical engineering survey of Pittsburgh and vicinity—its object, to put in concrete form what has already been done in this district in the way of smoke prevention—and that we may offer suggestive remedies best suited to each case in hand.

The relation of smoke to the health of the residents of a smoky city is an open question, one which can well be put on a scientific basis, in order to do away with the misunderstandings which are at present so common. This is here being done by an investigation conducted by eight physicians, each a specialist in his line. Some experimental work along pathological and bacteriologial lines is in progress at the present time, with more planned for. Observations, too, are being made which, with the aid of physicians in other places, will bring forth results of great assistance in establishing the true status of the problem.

It is a well-known fact that the gases produced during the burning of many coals are detrimental to the growth of plant life. Little, however, seems to have been accomplished in determining the damage done by the soot with its occluded tar and acids. A botanical survey of Pittsburgh and the surrounding country is being undertaken to determine the plants which will grow in the smoky district and those which will not. A large number of laboratory experiments concerning the effect of soot on plants are being performed by the botanist in charge of this branch of the work.

A meteorological study is being started to determine the effect on the weather, on the amount of sunlight cut off, on producing and lengthening the life of fogs, &c. (somewhat similar to the work which has been done in St. Louis and London).

A compilation is being made of the legislation which has taken place for the purpose of smoke abatement. This will comprise what has been done in England, France, and Germany,

as well as in the United States and Canada. Also a careful critical study, both constructive and destructive is being carried on as an aid to future legislation.

From the standpoint of æsthetics—and the city beautiful—the effect of soft coal smoke on buildings, decorations, &c., is of importance. Five architects are associated with us in this. In this line as in the others already mentioned the value of our study will be undeniably increased by the co-operation of people both here and abroad.

Neither is the scientific study of smoke itself neglected—for we are studying both its chemical and physical nature.

And last, but not least, is our psychological study of the gloom caused by smoke; its effect on efficiency—to what extent it is indirectly the cause of crime, &c.

At present we have associated with us in our study of the smoke problem in the city of Pittsburgh

1 physicist	2 economists.
2 chemists.	2 mechanical engineers.
5 architects.	1 meteorologist.
8 physicians.	2 lawyers.
2 botanists.	1 psychologist.

From this brief outline it will be seen that, while this investigation will be of great service to this locality under any conditions—still, if we can secure the co-operation of people in other parts of the world, likewise affected by this nuisance—comparative results can be obtained, which will enlarge our sphere of usefulness, not only to our immediate benefit, but as well to that of the world at large.

In conclusion I should like to ask the co-operation of anyone interested in any or all of the lines along which we are conducting our investigation. I should like to hear from anyone interested, I should be grateful for any suggestions offered, any questions asked, any references given, or for being put in touch with others similarly occupied.

Tentative Outline for an Investigation into the Economic Phases of the Smoke Problem.

By Professor C. W. A. Veditz, Ph.D., LL.B.
(Pittsburgh University).

So frequently has the smoke evil been discussed in most of our large industrial cities that the average city is quite willing to admit that smoke is ugly and unhealthful, and that it compels the inhabitant of smoky cities to spend more money to keep his clothes and his home clean than would be the case if smoke were dispensed with. Much smaller, however, is the number of persons who are convinced that smoke is unnecessary or, at all events, that it may be very greatly abated without imposing any economic burden whatsoever upon the industries that are the chief smoke-producers.

To secure effective results in the abatement and the ultimate extinction of smoke, it is felt by those in charge of the Pittsburgh investigation that at least two things are necessary.

1. The heads of the industrial enterprises that produce smoke must be convinced that smoke is not necessary, and that there are many devices now on the market that prevent smoke without ultimately increasing the cost of installation or industrial management.

2. The general public must not only be persuaded that the smoke evil is a serious one, and that smoke is unsightly, unhealthy and unnecessary, imposing upon the average family a considerable burden of cost ; but it should be possible to tell the average citizen approximately *how much* it costs him to tolerate the smoke nuisance, and approximately what monetary damage is done him by smoke production. He should be told in as concise and exact terms as possible what financial losses are attributable to each of the following items in the following general statement of the scope of our economic inquiry.

Public sentiment against a public nuisance is a potential force for reform ; but, unless it is backed up by well authenticated, specific facts and figures, it is apt to be frittered away in indefinite endeavour, and to accomplish nothing in the way of tangible results. An ounce of gunpowder placed on the ground and ignited accomplishes little or nothing ; but the same amount exploded behind a gun may be wonderfully effective. Similarly, well-directed, intelligent public demands, reinforced by authoritative evidence; will accomplish much more than ill-defined public sentiment.

The outline of our economic investigation is as follows :—

A.—The Home, Clothing, &c.

Limitation upon the choice of building materials and style of architecture, because of smoky atmosphere. [Gutters and rain conductors must be so arranged as to prevent the soot-laden water from splashing against the walls.] Restrictions as to colour and character of paint, because of the soot and acids in the air. [Architects here declare that wooden structures require one more coat of paint than elsewhere, and must be repainted about one-third more frequently than elsewhere.] Light colours must be avoided in furniture and furnishings, due to the great cost incurred in keeping them clean. The necessity for keeping windows closed as much as possible makes ventilating devices more necessary. Clothing, particularly of light colour, such as is necessarily worn in the hot summers in Pittsburgh, must be cleaned and laundered more frequently than elsewhere, and a larger original supply is necessary. This is especially true of laundering for men and the cost of cleaning or laundering light-coloured dresses for women. The speedier soiling of bed linen, curtains, rugs, &c., and resultant cost for cleaning. The effects of smoke on food and food-preservation (milk, &c.), the difficulty or impossibility of vegetable gardening in connection with housekeeping, the added burden of housekeeping attributable to smoke, and the greater neglect of children by the housewife in industrial communities because of this added burden. The effect of smoke on ventilation, heat and light of the household, especially the added cost of artificial illumination.

B.—Industries that Supplement the Home.

The amount of business done by laundries compared with that of a smokeless city. The use of chemical substances in laundering. The number and amount of business done by cleaning, scouring, and dyeing establishments. The added cost of management for restaurants and hotels, attributable to smoke. The cost of and necessity for cleaning devices of all kinds.

C.—Manufacturing Industries.

The expense imposed upon certain productive concerns through the necessity for having pure air, and therefore requiring devices for purifying the air ; *e.g.*, candy factories, dairies, textile mills, &c. The industrial cost of artificial illumination, for not only does the artificial darkness due to smoke make it necessary to use more artificial illumination, a factor which is fully determinable, but the productive efficiency of the operatives is probably diminished through the substitution of artificial for natural light ; this may mean that products are of poorer quality or of smaller quantity. The increased cost for ventilating devices. [To these might be added the effect of poor ventilation upon the health of employees, although this item is also referred to

elsewhere.] Finally, considerable evidence has already been collected with regard to industrial establishments that have refused to come to Pittsburgh because of the smoke evil, and the extra burdens of cost which this evil involves.

D.—Wholesale and Retail Commercial Enterprises.

Shops and stores dealing in commodities that are deteriorated by soot and smoke are compelled to take definite account of the losses entailed by these causes. [White textile fabrics and certain food products are peculiarly susceptible to smoke and soot.] Haberdashers, tailors, dressmakers, and milliners are compelled to take seriously into account these causes of damage to the goods which they handle. In the case of large department stores it will prove possible to obtain accurate data with regard to the above items of cost, and with regard, also, to the cost of cleaning windows, artificial illumination, &c.

E.—Office Buildings and Apartment Houses.

Specific data with regard to the cost of lighting, cleaning, and ventilating can be obtained from this source also.

F.—Public and Quasi-Public Concerns.

Some facts have already been collected with regard to the increased cost of managing hospitals in smoky cities compared with hospitals in cities having little or no smoke. For schools the effect of the items already mentioned should be studied, as well as the effect of smoke, poor light, and poor ventilation, upon the children and upon the school equipment—books, pictures, paper, &c. The same items represent a cost-factor in museums, art galleries, and theatres.

G.—Health Cost.

It appears to be conceded by most physicians that soot, although it is not a specific cause of disease, is an aggravant, a carrier and a culture for disease. Not only in England, but in this country, a number of studies have been made of the relation between smoke and disease. The effect of smoke—and especially of artificial light—on the eyes, and on the respiratory organs can hardly be regarded as beneficial. It will, of course, be a matter of great difficulty to express in terms of money the precise burden which smoke-caused disease imposes upon the community. It is conceivable, also, that there is some relation between industrial accidents on the one hand and smoke and darkness on the other.

* * * *

The above items, or most of them, will have to be studied comparatively ; that is to say, by determining how much more these things cost in Pittsburgh, because of the smoke, than they do in other cities where there is less smoke or none at all. It is

for this reason that successful results require that the investigation be not confined to Pittsburgh alone, but include as large as possible a number of communities. On the other hand, some of the factors will not admit of exact determination, but can only be approximated. We believe, however, that a very careful and intensive study of typical industrial establishments, of typical households, of typical office buildings, schools, hospitals, &c., supplemented by more general data concerning as large a number of these as can be reached, will give substantially accurate results. For instance, in determining how much the cost of artificial illumination for office buildings in Pittsburgh is increased by reason of smoke, we purpose to proceed as follows: To ascertain for a few carefully selected office buildings just how much is spent for electric lighting; then to collect similar information for office buildings of as nearly the same size and general character in other cities, having less smoke than Pittsburgh or no smoke at all; then, after making due proportionate allowances for differences in atmospheric conditions and other possible divergent conditions, during a given period of investigation, to draw conclusions to the effect that for office buildings of the kind studied, the additional cost in Pittsburgh (attributable to smoke) is X dollars and cents, or Y per cent. of the total cost of management, per annum.

Notes on the Smoke Abatement Problem, with Special Reference to Domestic Fires and the Smokeless Production of Steel.

By Professor W. R. E. Hodgkinson, F.R.S.Edin., Ph.D., F.I.C., F.C.S., F.G.S.

It has been stated that we are given to complaining and grumbling, but surely that is a libel, for the people of these Islands are easily pleased and do not grumble nearly as much as Continentals at the varied assortments of weather they have to endure.

Before the "strike" absorbed attention, there was much complaining in the early part of this year about the dull and sunless condition of the country in general and large towns especially, and the papers were telling us there had been only so many hours sunshine at this and that place.

We have had Royal Commissions on water supply with commendable results, but, so far, no care has been taken of the substance we must breathe. Anyone may pollute the air knowingly or ignorantly with little or no hindrance.

Part of the cause of this pretty constant dullness is certainly known.

There is no doubt whatever that where coal is used and "partially" burnt, much dust and, still worse, sulphuric acid and other substances are formed and thrown into the air.

In *The Times* of January 8, 1912, appears a statement from the *Lancet* "that the estimated fall of soot on the administrative county of London amounts to 76,050 tons per annum. This including 6,000 tons of ammonia, 8,000 tons of sulphates, and 3,000 tons of chlorine combined as chlorides."

Few non-scientific people can grasp what is meant by so many tons of a substance over a square mile, but to many of us these figure are startling enough, and call for very serious attention. There is no doubt, as the researches and observations of Dr. Aitken have shown, that an atmosphere free from, or even relatively free from dust and acid particles is scarcely able to produce fog or mist even when cooled below the dew point.

The manner in which coal is used, especially in the ordinary house fire, is eminently adapted to crowd up the surrounding atmosphere with particles of mineral dust, tarry vapours which condense into drops of semi-liquid stuff, and the oxidation products of the pyrites and other sulphur compounds contained in the raw combustible material. We are little further advanced as regards the ordinary house fire than our ancestors who

started the use of coal in fireplaces constructed for wood fuel. Practically, and in addition to a limited use of electricity and smokeless solid fuels, all that seems to have been done to combat this double waste of fuel and air in private households is the introduction of the gas fire with its asbestos radiator. But this does not completely stop the production of sulphuric acid, although the amount is much less from gas than from the original coal.

Dust is certainly avoided, but the failing of the asbestos fire is in the nature of the radiating material. It is a poor radiator. Rusty iron is much better, but unsightly when cold, and this offends the feminine æsthetic eye. A red clay containing much oxide of iron is superior to clean asbestos as a radiator.

But the number of gas fires is small in comparison to the open grate raw-coal fire. These are worse sinners than the tall chimneys of works, both intrinsically and from their greater number.

The employment of coke of different kinds in small fires is much better than coal, but still some sulphur compounds are retained to some extent even in the best coke, and oxidise or burn to sulphuric acid, which is one of the most effective fog producers we have, even in a comparatively dry atmosphere. But coke might easily be improved as regards its sulphur contents by treatment with lime in a way that could not be done with the original coal.

Gas coke if slacked with lime water (or weak milk of lime) becomes impregnated with lime, which retains to a great extent the sulphur, as a sulphate when the coke is burnt in an open grate. With prepared or briquette fuels this addition of lime could easily be made. Unfortunately nearly all these briquettes are made with some kind of pitch as binding material for waste coal or coke, and consequently produce both tarry and acid smoke.

As the central heating or steam heating of small houses is practically out of the question, the alternative is the use of cleaned coke or gas fires. I might suggest another plan; it is, however, most Utopian and not possible, excepting in the case of a garden city just commencing existence, or *planned* suburbs.

The idea outlined is to have each chimney of a house connected by a side flue conveniently arranged, with a main conduit laid under the roadway, this main leading to a central tower of considerable dimensions and height. The tower would serve as a water tower, destructor, or electric power station, or if there were works in the immediate district, as a collection of tall chimneys. The size of the tower would depend upon the number of houses to be drained and area of district, &c. Internally the tower would be one or several large chimney shafts. In addition to natural draught, there would be no difficulty in cheaply producing a draught by waste heat from destructors and the like.

The street conduit would be wide enough, some 4 ft. by 3 ft., to serve as a dust-catcher, and if so arranged that water could collect to the depth of a few inches only, much acid, ammonia, tar, &c., would condense. At street junctions chambers would be arranged for periodic cleaning, and also for equalising the draught in different sections of the system. This plan would not be difficult to arrange in combination with the present chimneys, as a simple damper could be arranged to control the artificial draught and cut off the ordinary chimney, &c., and the reverse. These details I have worked out, but they are not necessary here.

As the upcast draught in an ordinary house chimney never exceeds one or two metres of water pressure, the total suction required for 1,000 houses in which there are seldom more than two fires burning at once, in the main flue would not be excessive.

The cost would be considerable, but a little might be set off in the way of collected ammonia salts, &c., in the conduits and dust chambers.

The above *is* quite Utopian, but it may be remarked that with an artificial draught it could be arranged for the small fires to burn downwards, the ideal condition, for then on addition of fuel, the worst period of smoke production, the fumes of the decomposing coal must pass through the mass of red hot material, where it would become for the most part decomposed and burnt more completely than is now possible with an up draught and contact with the excess cold air entering the chimney above the fire. A practical underfed grate for house fires is yet to be invented.

Now as to the tall chimneys. They are inspected, and behave on the whole pretty well as far as black smoke is concerned. Dust and acids are emitted, and they are spread over a wider area than the smoke from houses.

The modern iron blast furnace is fitted with dust catchers, and the gases are taken off and used in such a manner that practically no smoke is produced.

Many steel works produce much smoke from heating furnaces, converters, and the like. Most of this is quite unnecessary and due to ignorance or laziness, in spite of an article in *The Times* Engineering Supplement, February 14, 1912, which makes an excuse for the good people of Sheffield for making the town into a sort of pre-Hades. A reducing, or at any rate a non-oxidising, flame or fire is certainly essential in working steel to preserve its properties, but the smoke escaping from the tops of the chimneys is too far away from the steel to have any effect.

A smith heats his metal *inside* a coke fire in contact with the coke. All that is required in any steel process is a non-oxidising condition, which can be obtained in any kind of re-heating furnace by adjustment of air supply without an enormous waste in the shape of distilled coal escaping from the chimneys.

Even the converters or cementation furnaces, which do require a decidedly reducing atmosphere, need not send out so much black smoke. It is merely a matter of more careful attention in firing and in the construction of the grate. What about furnaces driven by producer gas? Can they not be worked with very little smoke and be at the same time reducing or neutral? It would go badly with the open hearth processes of steel-making if this could not be done.

In the article in *The Times* Engineering Supplement the statement about smoke is somewhat too vague to be taken as basis of an argument.

If the statement refers to small steel articles, as tools, then this steel is mostly made by the converting or cementation process, in which the original high grade iron is heated with carbon in closed vessels. In this operation certain care must be taken that the flame actually striking these closed vessels is a non-oxidising one.

But it need not be so smoky as it generally is. When this steel is melted, for casting into ingots the fuel employed is coke, which gives comparatively little if any smoke. The steel in the crucibles does not lose carbon. In working the ingot into bar or rod it must be re-heated, and whether this be done in coke, coal, or gas-fired furnaces, there is no need for enormous volumes of smoke escaping from the shafts. That escaping smoke is not acting on the steel. It is quite easy to keep a reducing or non-oxidising fire by air supply adjustment.

It is possible to oxidise and spoil steel even in a smoke producing fire.

Producer gas-fired furnaces can be adjusted to be either "dry" or reducing.

Then again, when the final smaller operations of forging tools is done fires of small soft coke are generally employed, and as long as the steel tool is covered by the coke fire it cannot and does not lose carbon.

The cementation or converting furnace could quite well, and much more cheaply, be worked by producer gas, and the same with most re-heating furnaces for larger articles. Indeed, most of the larger things made in Sheffield are now heated in producer gas furnaces, and that alone has made a great difference in the atmosphere of the place. The waste of coal, as smoke, in Sheffield through hurry and ignorance is still great, and the steel produced is no better therefor.

Wasteful Power Production: With Special Reference to Waste Due to Smoke.

By Dr. John S. Owens, M.D., A.M.I.C.E.

The losses due to smoke may be dealt with under the following heads :—

(1) Losses due to the discharge of unburnt combustible material.

(2) Losses due to the effect of coating the furnace or boiler plates with a non-conducting layer of soot.

(3) The corrosive effect of soot on metal surfaces in the furnace, boiler tubes, dampers, &c.

Taking the first source of loss, it is found that unburnt fuel is discharged in smoke in the form of :—

(*a*) Carbonaceous soot.

(*b*) Tar vapours.

(*c*) Unconsumed gases.

For the present purpose (*a*) and (*b*) may be considered together as forming the visible suspended matter in smoke.

Domestic Smoke.

Owing to the conditions of combustion in ordinary domestic grates, a large proportion of the tarry vapours given off when fresh fuel is added escape as smoke. The temperature over the fire is kept very low by the air flowing in from the surrounding space, and the tar vapour has only a poor chance of burning ; hence we find about 25 per cent. of tarry matter in domestic smoke. It is now generally supposed that there may be a loss in soot of from 5 to 7 per cent. of the total weight of fuel burnt in domestic grates.

In some tests which I did a few years ago, by filtering the smoke from bituminous coal burnt in a small closed stove, I found that a yellowish grey smoke, of about shade No. 2 of the Ringlemann or Donkin scale, as seen across the top of a 3 in. stove pipe, gave a loss of approximately 1·6 per cent. of the fuel burnt. In another case I obtained a loss of 2·5 per cent. of the coal burnt.

In lampblack factories on the Continent, where the greatest possible amount of carbonaceous smoke is made, about 3·3 per cent. of the coal burnt is recovered as lampblack or soot ; but this contains very little tar. So far as our present knowledge goes, we may take it that an ordinary domestic fire burning smoky coal gives off from 2 to 5 per cent. of the weight of the coal as soot.

Factory Smoke.

There is much less smoke of the tarry variety given off by boiler furnaces than by domestic fires. The presence of a combustion chamber, maintained at a high temperature by the burning gases and the fuel, causes the tar vapours to be burnt up; the furnace door, too, prevents the access of large volumes of cold air, so that we get very little tarry matter passing up the chimney. The proportion of tar in factory smoke may be taken as approximately 1 per cent. of the weight of the soot.

The loss due to the escape of carbonaceous and tarry soot from boiler furnaces is much less than from domestic fires, and averages probably from $\frac{1}{4}$ to 1 per cent. of the weight of the fuel burnt.

The quantity of coal consumed in the United Kingdom during 1909 was approximately 177,000,000 tons, of which London alone consumed about 16,000,000. If we take the average loss in soot on the total weight as 2 per cent., we find that in this way alone over 3,500,000 tons of fuel are wasted.

Losses in Unburnt Gases.

The production of dense smoke means that the burning gases are being extinguished, from some cause, before combustion is complete. This is often due to insufficient air supply to the combustion chamber while the gases are being distilled off and burnt. Insufficient air means not only smoke but the escape of unconsumed gases, and these are a source of considerable loss.

Losses due to Coating the Boiler Plates or Tubes with Soot.

Soot is a very bad conductor of heat, and hence if a boiler plate is coated with it the rate of heat transfer through the plate is reduced. The actual loss in conductivity due to such a layer of soot appeared to me to be of sufficient importance to justify special experiments on the subject. In order to carry out these experiments, I first prepared a calorimeter consisting of a small polished metal vessel holding about 450 c.c. of water; this was fixed inside a larger vessel so that the bottom projected through that of the larger vessel, and the sides were surrounded by an air jacket. Both vessels were provided with lids, and through these projected a thermometer, the bulb of which was in the inner vessel; also the handle of a stirrer, which was intended to mix the water in the inner vessel to a uniform temperature. The exposed bottom of the inner vessel could be coated with soot to any desired thickness.

The method of using the instrument was as follows :—

A layer of soot was placed on the bottom of the inner vessel. This was done by making soot from a boiler furnace into a paste with water, so that it adhered to the vessel, the layer was then

carefully dried. The next step was to place exactly 400 c.c. of water in the inner vessel and replace the lids; the calorimeter was then placed on an asbestos sheet with a circular hole cut in it through which the bottom of the inner vessel projected, and in which it fitted exactly. The function of this sheet was to protect the bottom and walls of the outer vessel from the heat. A paraffin lamp was next placed under the calorimeter with its flame adjusted to a steady height; the thermometer was observed, and as soon as the temperature of the water reached 55 deg. F. the exact time was noted and the temperature of the water; subsequently the temperature was noted at intervals of about a minute until it reached 80 deg. F., when the exact time was again noted.

The soot layer was then measured by a micrometer or depth gauge and afterwards stripped off and the bottom cleaned, when the vessel was again filled with 400 c.c. of water, replaced on the stand over the flame, and the time and temperature noted as before.

Thus all conditions were kept as constant as possible in the two experiments, with the sole exception that in one the heat had to pass through a layer of soot, and in the other only through a clean plate in order to reach the water.

This experiment was repeated for different thicknesses of soot, and the results collected and analysed.

The accompanying curves (page 95) show graphically the influence of the soot in obstructing the flow of heat. The same results are given in the following table, in which the amount of heat passed into the water in a given time is expressed as a percentage of that passing through the clean, unsooted plate.

Thickness of soot layer, inches.	Rate of heat transfer as a percentage of that through clean plate.
·0	100
·05	86·3
·10	77·4
·15	70·0
·20	64·0
·25	59·0
·30	55·0
·35	51·8
·40	49·0
·45	46·8
·50	45·3

These values were found by drawing a fair curve through the experimental values and interpolating. In the curve Fig. 1 (page 95) the experimental values are shown. The percentages were obtained thus :—

Since the difference of temperature inside and outside the calorimeter was the same for all experiments, the rate of heat

transfer should vary inversely as the time required for the same rise of temperature. Suppose, as in the experiment with a soot

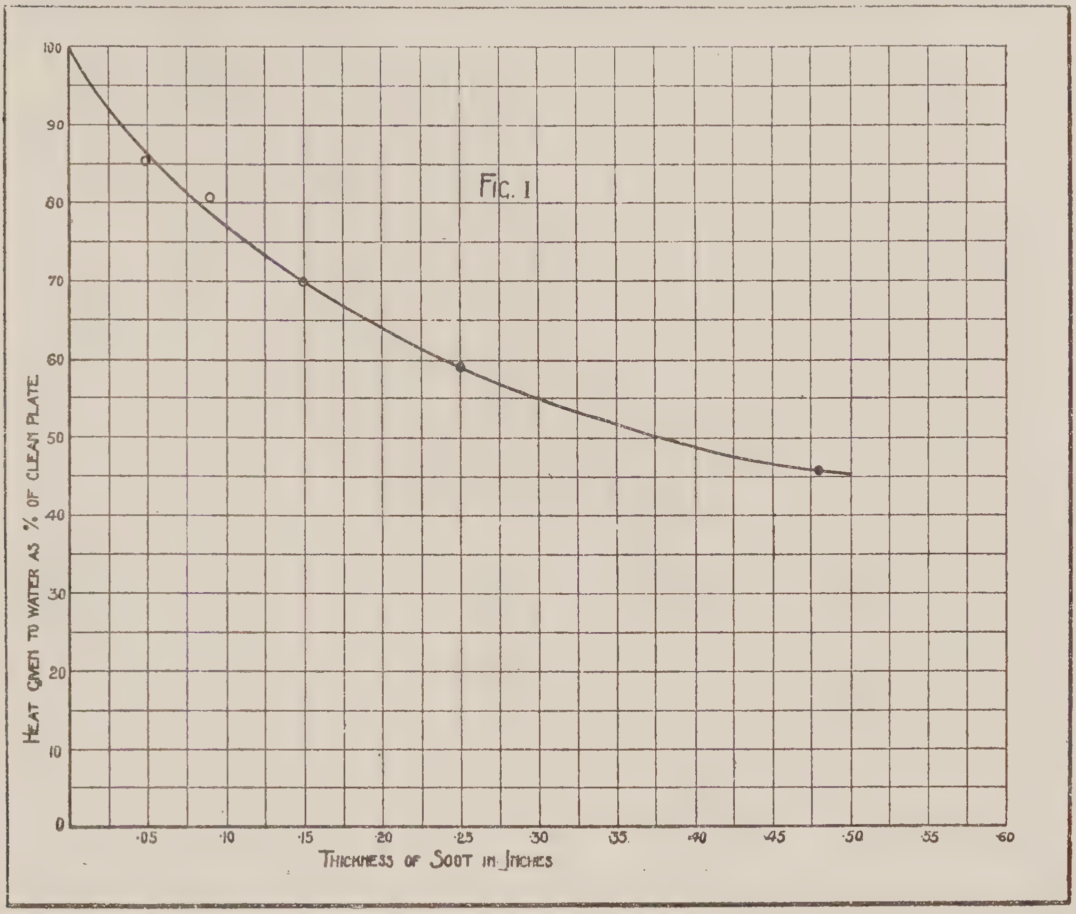


FIG. I

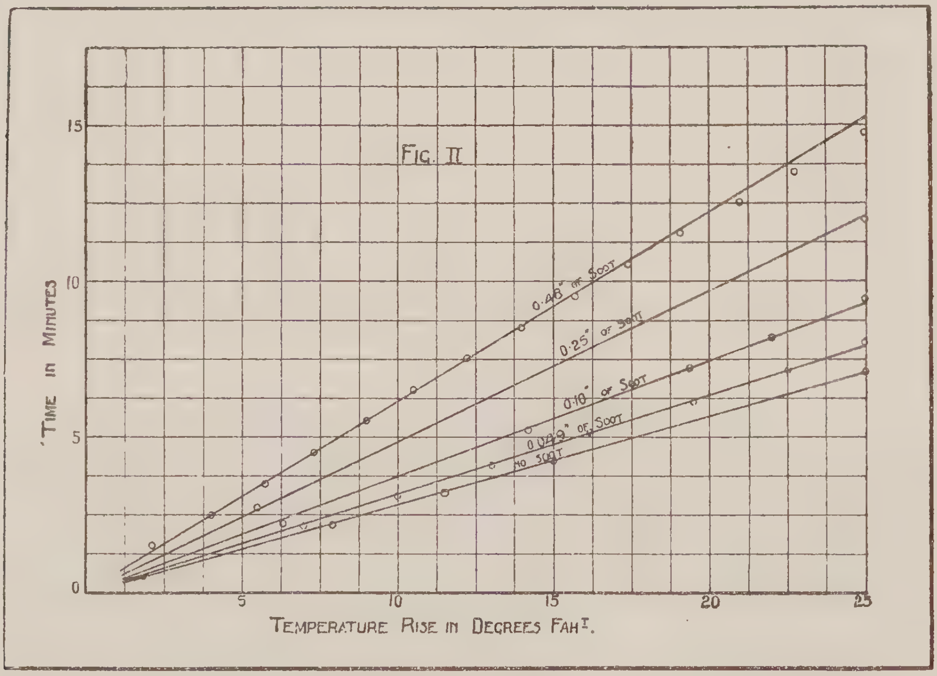


FIG. II

layer ·049 in. thick, the time required to raise the temperature from 55 to 80 deg. F. was, with the clean plate 6·83 minutes, and with the soot-covered plate 8 minutes, then, calling the

rate of transmission through the clean plate 100, and the rate through the sooty plate = R,

$$\frac{100}{R} = \frac{8}{6{\cdot}83}$$

$$R = \frac{683}{8}$$

$$= 85 \text{ nearly};$$

or the rate through the sooty plate was only 85 per cent. of that through the clean plate.

In these experiments the layer of soot was formed by making a paste of soot and water; this is not strictly speaking similar to a layer of soot deposited by smoke, but owing to its greater density it probably conducted heat better so that the results are likely to be more favourable than they really are in practice. when boiler tubes or plates become covered by soot. Under the latter circumstances it has been shown that there is a rise in temperature of the flue gases due to the diminished absorption of heat by the boiler. It will be seen from the table and curves that the loss which may result from soot deposit on heating surfaces is a very great one, amounting to 15 per cent. for a layer of soot only one-twentieth of an inch thick.

Corrosive Effect of Smoke.

The effect of smoke when deposited upon exposed metal surfaces is often highly corrosive. The soot owes this quality to the presence of sulphur acids derived from the sulphur in the coal. The presence of moisture greatly increases this corrosive effect; in fact, in the experiments just described, the bottom of the calorimeter was nearly corroded through before the experiments were finished, and any iron or steel article which came in contact with the soot paste referred to was rusted badly in the course of a few hours. This property of soot must tend to lessen the life of boiler tubes and plates exposed to it. Again, we must consider the cost of removing the soot from such tubes or plates, as this is an expense which smoke producers have to incur.

Losses due to Inferior Stoking.

It is a very curious thing that so little effort is made to ensure a knowledge of the first principles of their calling in the men whose business it is to feed the fuel to a furnace. It has been shown that a bad stoker may burn 15 or 20 per cent. more fuel than a good one to get the same effect; and while doing so he usually produces a great deal more smoke than necessary. In fact, it is well known that smoke production and wasteful combustion go hand in hand. And although it might not pay a manufacturer to educate his stokers, or employ more skilled labour, in order to save the proportion of the fuel which is lost

in soot alone; it would certainly pay him to see that the method of stoking is such as will give the best economy of fuel and the most perfect combustion. The steps taken to attain this result would also do away with smoke production to a great extent.

It is not sufficiently realised that while any man of common intelligence can shovel coal into a fire, a little extra knowledge of the principles of combustion and of the most effective methods of stoking would often save an employer ten times the amount which he pays to his stokers, to say nothing of preventing smoke. It would be an excellent thing if some system of instruction for men whose business it is to attend to furnaces could be more generally recognised as essential. It is probable that if certificates of efficiency were issued to stokers who had undergone a course of instruction, the advantage of employing such men would soon make the certificates of such value that few uncertified men would be employed.

It may be useful here to review shortly the processes taking place in a furnace burning bituminous coal, prefacing this by a reminder that all smoke from coal is derived from the volatile matter which is distilled off in the early stages of combustion, and that it results from the incomplete combustion of the tars and gases thus produced. This incomplete combustion is due to two main causes:—

(1) Cooling of the vapours or gases below their ignition temperatures—from 1,100° to 1,250° F.—before they are completely burnt.

(2) Insufficient air at the right place and time, or what amounts to the same thing, bad mixing of the air and gases.

With these points in view, consider a furnace which has just been stoked. There are two factors which tend to reduce its temperature:—

(*a*) The heat absorbed by the fuel in raising its temperature to ignition point.

(*b*) The heat absorbed in converting the solid fuel into gas, that is the latent heat of the gases evolved.

Both these losses occur before the new fuel gives off any of its heat, therefore the first effect of fresh fuel is to cool the fire. Also the greater the charge of fuel added the more heat will be abstracted in a given time. Thus we see that at the very moment when the volatile gases and tars are being given off, and when we require the highest temperature to burn them, we get the lowest. This consideration shows how very important it is to feed small charges at short intervals rather than larger charges at longer intervals.

A series of experiments by M. Burnat showed that when charges of coal of 13 lbs. were fed at short intervals an increase of efficiency of from 3 to 8 per cent. was obtained as compared with the same furnace fed with 55 lb. charges at longer intervals.

Again, an automatic arrangement which partially closed the damper when the furnace door was opened for stoking produced an increased evaporation of from 14 to 15 per cent. entirely due to this arrangement. This acted simply by reducing the rush of cold air into the furnace, and also preventing the temperature of the combustion chamber from being lowered as much as it otherwise would have been.

Smoke preventing appliances which depend for their action upon jets of air blown into the furnace above the fire, either through the door or dead plate or through the bridge, are too well known to call for any description. It may be mentioned, however, that such appliances will often give practically smokeless combustion with an inferior type of coal. Thus indirectly they are a source of saving to the manufacturer.

These examples show that there is a great economy of fuel to be made by working furnaces in the best possible way, instead of leaving everything to the skill, or rather absence of skill, of untrained stokers.

In this connection it is interesting to consider the advantages of mechanical over hand stoking. A furnace consumes fuel continuously; but, by hand stoking, it has to be fed periodically, whereas a continuous feed of fuel is what is required. This can only be effected by the use of mechanical stokers. Again, when the stoker opens the furnace door to fire up, a loss is incurred by the admission of air; there is no such loss with properly designed mechanical stokers. These two factors alone indicate the superiority of the mechanical over the hand-fed furnace.

Water in Coal.

Another source of loss is the water present in coal; this often reaches an unnecessarily high percentage, and every pound of water fed into the furnace in the coal carries off not only the 966 B.T.U. required to change it into steam, but also the steam is discharged at the flue temperature. Suppose the latter to be 560° F. and the air temperature to be 60° F., we have a loss for every pound of water of $966 + 152 + (348 \times \cdot 48) = 1{,}285$ B.T.U.

This is a very serious loss if the percentage of water in the coal is high; and it could be minimised if manufacturers refused to accept delivery of coal in which the water exceeded a certain percentage, say 5 for ordinary coal and slightly more for slack.

There is always a great and reasonable objection on the part of manufacturers to scrap their old plant and instal new; and unless it can be shown that such a proceeding is a financially sound one it will not be adopted. That it would be sound in many cases there is no doubt, but each case must be dealt with on its merits. There are, of course, many appliances on

the market intended to improve the economy of combustion, for which the most extravagant claims are made ; and this is rather a pity, because it destroys one's confidence in the soundness of the claims even when they may be quite honestly and correctly made. It is therefore important that steps should be taken to establish by proper scientific inquiry and tests the value of any particular appliance before installing it.

In conclusion, I would say that economy of fuel is not a thing which concerns the user only, although he is more immediately interested ; it also concerns the nation, since our prosperity is largely due to our possession of great stores of fuel in the coal fields, which stores are unfortunately dwindling at a more rapid rate than is necessary, and it behoves us to conserve them in every possible way.

Stoking.

By Commander W. F. Caborne, C.B., R.N.R, F.R.A.S., F.R.G.S.
(Hon. Secretary, Royal Meteorological Society).

At the Conference on Smoke Abatement held in London in 1905, under the joint auspices of the Coal Smoke Abatement Society and the Royal Sanitary Institute, in a paper on "Stoking and Smoke Abatement," I ventured to lay it down as an axiom that good stoking is the main factor in the prevention of the emission of smoke from furnaces; adding, that it might be broadly asserted that an intelligent and well-trained stoker would often obtain better results from indifferent coal than would a less expert man with superior fuel. My contention was that the skilful workman not only avoids committing a smoke nuisance, but at the same time effects a considerable saving of coal, to the benefit of his employers.

I did not overlook the fact that the quantity and the nature of the coal used, as well as the design and construction of the boilers, furnaces, &c., have also an important bearing on this question.

Or, again, that the forcing of inadequate boiler power is one of the prolific causes of factory smoke; and that this forcing is due in many large towns to lack of room for the additional boilers required by factories owing to the expansion of their trade.

The issue of much smoke from the shafts of manufactories and other commercial buildings does not necessarily indicate, as is sometimes erroneously asserted, great industrial prosperity, but rather carelessness, ignorance and waste by man, or inefficiency in the appliances employed.

It has been repeatedly proved that wherever energetic steps have been taken to abate the industrial smoke nuisance, the result has been great economy in the annual fuel bills.

My whole argument was, and is, founded upon the paramount importance of the personal equation in the suppression of the emission of smoke.

In the discussion in 1905, one speaker was desirous of eliminating the personal element as much as possible, as he pinned his faith on mechanical stokers. Other speakers preferred hand-firing; and it may be remarked that with mechanical stokers it is impossible to altogether get away from human agency and control.

In 1905, the Coal Smoke Abatement Society made inquiries

of certain firms from whose manufactories or chimneys no smoke nuisances had been observed during the previous six months; and out of 32 firms 13 mainly ascribed their success to *careful stoking*. In analysing and summing up the replies received, Dr. S. Rideal remarked that, though not denying the efficacy of many mechanical devices, yet the general consensus of opinion favoured skilled and careful hand stoking as of the first importance.

Much technical knowledge is required by a stoker in order to enable him to perform his important duties in this age of huge, delicate, and powerful boilers, but until 1906 practically nothing was done in this country to further the instruction of these men.

Again, in giving some extracts from "Reports on the Laws in Force in certain Foreign Countries in regard to the Emission of Smoke from Chimneys," presented to Parliament in 1905 (the information having been furnished to the Foreign Office by His Majesty's representatives abroad, while the return itself was due to the initiative of the Coal Smoke Abatement Society), I drew particular attention to the fact that in 1902 the Prussian Government had authorised courses of instruction for stokers, and in the Budget had allocated a sum of £2,000 per annum for that purpose.

I will not recapitulate the motives which actuated the Prussian authorities in adopting that course, nor repeat the instructions that they then issued, but at the conclusion of my own remarks I said: "I am of opinion that, as regards the efficient training of stokers, we might well adopt some plan analogous to that inauguated by the Prussian Government in 1902. However, I would substitute municipalities and county councils for the State, the more so that those bodies have already many facilities for the instruction and examination of candidates desirous of obtaining certificates of proficiency. If instructional courses for stokers were instituted, and if employers would give a preference to those persons who had been properly trained and could produce documentary evidence of the fact, the result would go far towards mitigating the smoke nuisance, and would, at the same time, effect an enormous saving of money now constantly wasted through the imperfect combustion of coal."

In a little book entitled "Boilers and Boiler Control," Mr. John B. C. Kershaw says that "bituminous fuels produce nine-tenths of the smoke that darkens the atmosphere of our cities and centres of manufacturing industry. Two forms of smoke are obtained from this class of fuel. The first is due to the escape of unburnt hydrocarbon gases accompanied by minute sticky globules or vesicles of tar: this is the character chiefly of domestic or house smoke. The second form in which smoke occurs is due to the separation of carbon in the form of soot or 'blacks' from a smoky yet luminous flame, when it

strikes a cooler surface of metal or brickwork. The smoke produced by steam boilers and furnaces of all kinds, immediately after firing, is chiefly of this type, and is usually referred to as *factory smoke*. . . . As regard factory smoke, this can be almost entirely avoided, even when burning bituminous fuels, if the three principles of good combustion are closely adhered to. These are: (1) A sufficiency of air; (2) a sufficiently high temperature; (3) a good mixture of the air and of the hydrocarbon gases."

An American writer has stated that: "It is obvious that the proper training of firemen has been sadly neglected. An intelligent fireman is worthy of good pay, but many of them doubtless waste more than their wages daily because of either ignorance or carelessness in handling their furnaces. This is especially true in small plants, and small plants preponderate in every city, and in these plants the possibility of great economies through the installation of mechanical stokers is small. Yet firemen can hardly be expected to know intuitively the chemistry of combustion, and certain it is that they have never been instructed in the fundamental principles of their occupation. Muscle and endurance have been considered the chief elements in the make-up of a fireman; and the arduous duties, too often performed in dark, hot, and ill-ventilated basements, have not attracted many men of intelligence."

In an appendix to a paper read by Mr. G. B. Storie, at Manchester, in 1911, the following paragraph occurs:—"The effects of good and bad hand-stoking are often very marked. Some years ago a prize competition in hand-firing was carried out at Sheffield, and the difference between the best and the worst man made a gain of 22 per cent. in evaporation and 18 per cent. in boiler efficiency with conditions exactly the same in each case."

In regard to railway smoke, Mr. George W. Welden, superintendent of motive power on the New York, New Haven, and Hartford Railroad, in a paper on "The Smoke Nuisance on Locomotives," in 1907, remarked: "It will be quite apparent to the candid reader of what follows . . . that *the fireman*, or 'stoker,' is all-important in smoke prevention. In the instance just following, a saving of 43¾ per cent. of coal is credited to the capable fireman, but it does not appear that the capable fireman personally profited by his better work. A standard of proficiency in stoking a locomotive, with prizes or better pay for economical results, will certainly help bring the answer on the railroads."

"Mr. Angus Sinclair, President of the Society of Locomotive Engineers, relates his experience with two firemen on the same locomotive, running the same distance, on two successive days. The first fireman, in one hour and fifty-five minutes, the time occupied in the run, used 8,000 lbs. of soft coal, making steam

with difficulty, and filling the atmosphere with smoke. The next day another fireman, with the same engine, running the same distance, used 4,500 lbs. of the same coal, with plenty of steam and no smoke. The result was a saving of $43\frac{3}{4}$ per cent. of coal, and no annoyance from smoke. As the first condition is pretty nearly universal on roads where soft coal is used, the loss from ignorance or carelessness must be enormous."

Enough has been said to prove what valuable assets well-trained stokers are, and the need that exists for technical schools for the careful instruction of men desirous of becoming efficient firemen. Something has been done in that direction, but not nearly enough.

It has been already shown how the Prussian Government took the matter up in 1902; and in the same year a voluntary association of steam users, known as the Hamburg Smoke Abatement Society, was formed, one of the objects of which was the education and control of firemen in the proper performance of their duties.

Coming to our own country, and to the Coal Smoke Abatement Society, it was decided in 1906 by the Executive Committee of that body to make an attempt to establish instructional classes for stokers in London. With the support of the Principal, Mr. C. T. Millis, this was accomplished with great success at the Borough Polytechnic Institute in 1907; and the financial difficulties at first experienced have been partly removed during late years by a grant for technical education made through the Education Department of the London County Council.

The classes have always been well attended, and this winter an elementary course of instruction has been given at the Borough Polytechnic by Mr. W. H. Hildred; while an advanced course of lectures has also been given there by Dr. J. S. Owens, both under the auspices of the Coal Smoke Abatement Society, the fee for the former course being 3s., and for the latter 5s.

Hitherto, only certificates of attendance have been granted, but it is hoped that in the immediate future certificates of merit may be issued.

It is satisfactory to note that the example of the Coal Smoke Abatement Society has been followed at Glasgow, Liverpool, Manchester, and elsewhere, and I trust that the many municipal delegates attending this Conference will be able, in their own towns, to induce their Councils to formulate classes for the training of stokers as part of the ordinary curriculum of their technical institutes.

Solid Smokeless Fuel.

By W. D. Scott-Moncrieff.

In a letter which appeared in *Nature* on December 16, 1880, under the title of "Smokeless London," I suggested to gas companies a new method of treating coal. I wrote :—

"Instead of taking 10,000 cubic feet of gas per ton from the coal, I propose to take 3,333 cubic feet, and to pass three times the quantity through the retorts, or any other proportion that may be found most convenient. The result of doing so is startling. The companies will have doubled the quantity of bye-products they have at present in the shape of tar and ammoniacal liquids ; the community will have 24-candle gas instead of 16-candle gas ; the fuel resulting from the process will light readily, and it will make a cheerful fire that gives out 20 per cent. more heat than common coal. London would become a smokeless city."

This letter was followed by a paper which I read before the Royal Society of Arts a few weeks afterwards. On that occasion the chair was occupied by the late Sir Robert Rawlinson, the chief engineer to the Local Government Board, and the late Dr. Angus Smith wrote stating that if the ammonia contained in the smoke of the United Kingdom could be recovered the agricultural equivalent would enable this country to become an exporter instead of an importer of wheat.

One of the propositions laid down in the paper was that the proper bodies to carry out the proposals in a practical form and on a commercial basis were the gas companies. The professional opposition to the proposals was very pronounced, and the first expression of it came from the manager of what was then the Phœnix Gas Company, of which Sir Robert Rawlinson happened to be a director. He reported that the scheme was impracticable on account of the difficulty in drawing the charges of partially coked fuel from the retorts, the excessive amount of smoke, and the effect the water used in quenching the hot discharge had in making it friable and of little value when obtained.

There the matter rested until 1905, when there was a conference held at the Horticultural Hall in connection with a Smoke Abatement Exhibition. On that occasion I joined in one of the discussions and referred to the proposals I had made in 1880. The papers read at the conference were divided into the following three groups :—

(*a*) Those containing proposals for dealing practically with the problem of smoke abatement. (*b*) Those taken up with the facts and figures of the evils arising from smoke and fog. (*c*) Those that dealt with the law, and its application, on the subject of smoke. In the writer's judgment, the most important contribution to the discussions at the Horticultural Hall took the form of an admission on the part of Dr. Des Vœux that, "broadly speaking, it may be said that there is no such thing as a smokeless open coal fire." It is only from knowing something of the efforts that have been made to prove the reverse of this proposition on the part of inventors and manufacturers that one can appreciate the significance of such a statement. It is never very safe to prophesy in matters of invention, but, to the writer, it always appeared self-evident that the process of burning bituminous coal in any conceivable open grate was not likely to be successful in the matter of smokelessness, seeing that it required six hours in a red-hot retort, with experienced labour and skilled supervision, to complete the process of gas extraction.

At the same conference a paper was read by the late Sir Charles Cookson, in which he referred to "a newly invented and more economical pattern of coking oven at work in Germany," which provided a "charred coal," this term being used as descriptive of the same kind of material as that advocated at the Royal Society of Arts. The article in the *Journal of Gas Lighting* concluded with a further expression of the opinion that the gas companies were the proper bodies to carry out the work.

In 1906 patents were taken out for improvements on the lines already described, and subsequently the public were invited to subscribe to a company with a large capital for exploiting the patents commercially.

This is not the occasion, nor would it serve any good purpose, to refer to the history of this company, but the public have a legitimate interest in knowing something about the practical reasons why a process which has been supported by great sums of money should not, so far, have proved as successful as some of its shareholders had hoped. On November 30, 1907, an article appeared in the *Gas World* which referred to one of several patents owned by this company, and the writer only refers to it because the patentee explains very clearly in this particular specification some of the difficulties he had to contend with. He says: "I have experienced difficulty in effecting complete gasification of the coal and in the production of an homogeneous partially coked fuel by reason of the caking of the coal near the surface during the process of distillation."

The remedy was embodied in a claim for "the application of heat to the coal to be treated, gradually and slowly."

The writer will now go on to refer to some information he has quite recently obtained from one of the gas companies who have made an honest and hearty attempt to supply their customers, who asked for it, with a smokeless fuel that should not have the faults of fully degasified coke. The writer is informed that so far as they have gone the production of such a fuel is still surrounded with difficulties, some of them in the direction of those just referred to, and that there is such an absence of any immediate prospect of satisfactory commercial results that they have serious thoughts of giving up the supply.

In contrast with this experience, reference may be made to a contribution from Professor Vivian B. Lewes, which appeared in the *Gas World* of March, 1908. He makes the following comparisons, and argues, as the writer did thirty years ago, that not only does partial extraction of the gas from bituminous coal produce a good smokeless fuel for burning in domestic grates, but that the process of arresting the distillation of the coal yields more profitable results in the production of higher priced materials from the tar, which are in constant demand.

The following are the figures given by Professor Lewes :—

Comparison of Cost of 1,000 Cubic Feet of Gas Made by High and Low-Temperature Carbonization.

High Temperature.	d.	Low Temperature.	d.
Coal at 11s. 6d. per ton	13·30	Coal at 11s. 6d., 4 cwts.	26·50
Purification	0·50	Purification	0·50
Salaries	0·54	Salaries	0·54
Wages	2·25	Wages[1]	2·25
Maintenance	3·45	Maintenance[2]	2·21
	20·04		32·00
Residuals.		*Residuals.*	
Coke, 0·82 cwt., at 12s. 3d.	6·11	Coke[3], 2·4 cwts., at 12s. 3d.	17·64
Tar, 0·9 gall., at 1·5d.	1·30	Tar, 4·6 galls., at 1·5d.	6·90
Ammonia products	2·11	Ammonia products	2·80
	9·52		27·34
	20·04		32·00
	9·52		27·34
Cost of 1,000 cubic ft. of 14 candle-power gas in holder	10·52	Cost of 1,000 cubic ft. of 20 candle-power gas in holder	4·66
Calorific value—B.Th.U.	592	Calorific value—B.Th.U.	750
Sulphur per 100 cubic ft., grains	45	Sulphur per 100 cubic ft., grains	18

It is not proposed to argue from other figures obtained from experts of great practical experience on a large scale of production. They are very different from those given by Professor Lewes, but as there is no means of identifying and estimating the effect of varied conditions in production, the arguments would be interminable.

One of the points raised against any process that yielded excessive quantities of tar was that the supply would far surpass the demand so that the value in money would become negligible. This no longer holds good if Professor Lewes is right about the low temperature tar yielding large quantities of motor spirit.

Summing up the evidence that is available from one of the large gas companies and two companies who have patents for systems of partial extraction, the writer has arrived at the following conclusions, viz. :—(*a*) That the proposals he made in 1880 of only extracting a part of the gas from the coal and using the residual fuel as an improved substitute are sound both from a scientific and a commercial standpoint. (*b*) That the object of every gas company has hitherto been not to make a partial but the greatest possible extraction of gas from the coal in their retorts, and that this practice will continue until they are convinced that it is worth their while, from the point of view of their dividends, to alter their plants and the general routine of their business. (*c*) That they now regard their proper function to be the selling of gas to their customers, and look upon the production of coke and tar as subsidiary items. (*d*) That so long as this is their policy they are not likely to exert themselves to produce a fuel which is smokeless and better than coke, nor a better material than their ordinary tar. Since gas of a low illuminating power is now in general use, the high candle-power of the gas produced from an arrested distillation does not appeal to them at all. (*e*) That nevertheless the gas companies are the proper persons to produce a good smokeless fuel and more valuable tar, because they must always have much better opportunities for selling their gas than private companies who must find new customers for all they do not require themselves. (*f*) That a great amount of prejudice has already been overcome and that the gas companies are only waiting to be convinced that the adoption of partial extraction will yield a good commercial return for the expense and trouble it must entail.

Coming now to the practical point as to how far the system of arrested distillation may be regarded as the best solution of the smoke problem, the writer has come to the conclusion, on the strength of recent experience and experiment, that he was justified in 1881 in regarding it as the best solution of the problem, both commercially and from the point of view of the community, always presuming that certain difficulties could be overcome. The objections have now been reduced to two, viz. : (1) Irregularity in the quality of the material produced arising from uneven conditions in the retorts due to caking. (2) The effect of low temperature extraction in producing gas so rich in tar that it is not conveyed away but remains behind in the

retorts and is not only lost as a bye-product, but deteriorates the quality of the fuel.

Although these two are the only remaining difficulties that the writer knows of, it must not be supposed that they are unimportant because they are not numerous. The first leads to complaints from customers that some of the fuel is no better, if so good, as ordinary coke, and this makes the process a commercial failure. The writer, after a continuous experience of more than two years, having had no fault to find, is told that he has been peculiarly fortunate. The difficulty in removing the tar along with the gas has apparently been overcome by extracting it under a partial vacuum. This is a simple and should be an effective remedy.

It seems as if only one difficulty remains, that of irregularity in production due to caking in the retorts, and the writer thinks that this cannot long defy the ingenuity of invention.

One advantage of the system from a commercial standpoint must be admitted even by the most prejudiced gas manager, and that is the saving in wear and tear and the constant worry as to when and how to make renewals, due to the high temperatures now in vogue compared with the low temperature required in the case of partial distillation.

The writer has refrained from offering any criticism of the various exhibits of smokeless fuel, as their advocates will no doubt explain them in the light of what he has written, if asked to do so. He wishes them every success. One exhibit is interesting in having introduced the well-known chemical action of gunpowder in which the oxygen of the nitre combines with the carbon and sulphur. The progress of this invention will no doubt be followed with great interest.

A paper on the subject of solid smokeless fuel would not be complete without some reference to anthracite, which has been the means of solving many of the smoke problems in great cities in America. The writer cannot do better than quote from a paper read at the Eastbourne Congress of the Royal Institute of Public Health by the late Sir Charles Cookson, in which he says: "Of anthracite at the present moment the total output is from 2,000,000 to 2,500,000 tons per year, of which the consumption in London is less than 500,000 tons and only 1 per cent. goes for domestic purposes. But it would take 4,000,000 or 5,000,000 to supersede bituminous coal in London alone. The output certainly admits of a great increase, and it might probably be doubled if there was a sufficient demand, and the deficit might be made up by import from the practically inexhaustible coalfields of America. Unfortunately, however, there appears but a small chance under present circumstances of anthracite from either source not rising to a price which would put it out of the competition."

Suction Gas Plants.

By George A. Goodwin, M.I.C.E.
(Past President Society of Engineers; Whitworth Scholar).

This Exhibition has for its primary object the education of the public in the most modern methods for the abatement of coal smoke, whereby the atmosphere will be rendered purer, healthier, less injurious to works of art, sculpture and buildings, and the more economical generation of motive power. I do not pretend that this paper is highly technical, as I consider this neither the time nor place for many technicalities, but rather for making better known the general features and advantages of the suction gas system of generating motive power.

As factory and works chimneys are great culprits in the emission of smoke the subject is most important, dealing as it does with the means of doing away with the formation of smoke and giving many other important and pecuniary advantages.

Producer gas, as it is generally called (because it is generated in a producer) covers what is now known as suction gas. It was first used by Mr. Frederick Siemens in 1857, combined with a regenerative furnace system for the melting of steel, and in this case the gas so formed was taken direct to the furnace without cleaning.

In 1878 Mr. J. E. Dowson introduced the use of steam mixed with air which passed through the producer, as well as other apparatus for washing and purifying the gas on its way to the gas engine, and, in fact, produced a complete gas plant suitable for use in factories.

The first makers of suction gas plant in this country were Messrs. Crossley Brothers, in 1901, so that eleven years' valuable experience has been available. Before this period producer gas was made and used under pressure, a system involving the use of a separate steam boiler (invariably coal fired) and a gas holder, both of which are dispensed with in the suction system.

Enormous strides have been made, and improvements in detail are still constantly being developed. The working of suction plants has been highly satisfactory, and many large plants even up to 1,500 h.p. have been successfully put to work. These large powers have, however, been worked from gas made in the blast furnace or from special producer plants made on a large scale, and where the recovery of by-products, such as ammonia and gas tar, is an important part of the undertaking.

The largest power I know of worked by self-contained plants is about 220 h.p. in *one* engine, but this, of course, can be easily increased by coupling two or more engines together. In many cases these plants have displaced steam and oil engines, and even electrically driven installations, where the current was obtained from public supply stations, owing to the comparatively high cost of current.

There cannot be much doubt as to the desirability of converting solid fuel, such as coal, into a combustible gas in a closed chamber preparatory to burning it to develop and use its energy. The gas is suitable for heating as well as for the generating of power.

Originally producer gas was made by passing air alone through a deep fire of incandescent fuel, with the result that the carbon-dioxide first formed at the lower strata of the fire passed upwards, where it combined at the higher strata with more carbon, and left the producer as monoxide, in a condition that it became explosive when mixed with the correct quantity of air, say in the cylinders of gas engines.

The result of Mr. Dowson's system of mixing steam with the air before entering the furnace brought about the following results :—(1) The gas was cooler, so enabling a greater weight of charge being drawn into the cylinder of the gas engine, thus producing a more powerful explosion; and (2) the temperature of the furnace was kept down, thus reducing the formation of clinker and rendering it less adherent, at the same time prolonging the life of the furnace fire-brick lining: all most important practical improvements.

I will now briefly refer to the detailed construction of the plant.

Furnace.

This is generally cylindrical, lined with fire-brick blocks with a backing of some non-conductor of heat, such as sand, slag wool, or the like. At the bottom are placed the fire bars to carry the fuel, which rises up into the lower portion of a superimposed vessel, forms a bell as an extension of the charging hopper, and acts as a distilling chamber. The hopper has double charging valves in the upper portion, permitting the fuel to be inserted through the upper valve, the lower valve being shut, and so arranged that when the upper is closed the lower can be opened, permitting the charge to descend into the furnace without admitting air. Other devices are also used giving the same results, such as a rotating hollow cylindrical valve with a hole in one side, thus making a connection alternately with the hopper and distilling chamber, but never with both at once.

As regards the material of the furnace shell, some firms make this entirely of cast iron, others of wrought steel with cast-iron ash pits, but this is not a matter of much importance.

As regards clinkering operatings, some firms provide holes in the top of the producer through which clinkering bars can be inserted, others rely on clinkering through the fire hole doors, in which case the ashpit with a wet bottom gives the best results, because when cleaning the fire hot ashes fall into the water, creating steam and thus preventing too dry air entering the furnace, which would otherwise impair the thermal value of the gases.

Vapouriser.

At the top of the furnace immediately surrounding the lower extension of the hopper are sometimes placed the vapourisers, while in other cases the vapourisers are either entirely external or combined with an internal one. These are either of the type known as "Bulk," containing a quantity of water in bulk, and over which the air supply is passed; or of the "Flash" type, where there is no body of water but it is allowed to simply drip over the hot surface round which the air is passed, so becoming saturated on its way to the ash pit.

The vapourisers, when internal, are encircled by the heated producer gases on their way to the scrubbers and thence to the engine, the fire-brick lining being built up close to the bell on the gas exit side, so that the gases cannot take a short cut to the exit but are compelled to circulate.

Cold air, or in some cases air pre-heated by circulating round the shell of the furnace, which increases its saturation capacity is admitted to the top of the vapouriser, where it becomes well saturated with steam, after which it is led down to the ashpit and drawn through the furnace by the suction of the engine, thus producing the required gas, a mixture of carbon monoxide, hydrogen, and nitrogen; which last, unfortunately, cannot be eliminated.

When the vapourisers are external they are generally made to surround the down pipe carrying the hot producer gas to the scrubber, so that it will be seen that in both cases the vapourisers absorb a considerable quantity of heat that would otherwise be wasted. In some makes of producers further provision is made for heating the air and water by making them circulate round the delivery gas pipe preparatory to entering the ashpit, so that what would otherwise be wasted heat is utilised, and a regenerative action brought about.

The supply of water to the vapouriser is sometimes effected by tanks and automatic floats, keeping the water in the "Bulk" type at a constant level, but generally the water is led by supply pipes and allowed to visibly drip into cups which lead to the vapouriser, so that the supply is seen, easily regulated, and when once fixed requires little attention. The amount of water is so adjusted that there is just a slight drip overflowing from the vapouriser, which drip is led down either into the ash pit or into a sump. The overflow is of course kept as small as possible.

Scrubber.

The producer gas after leaving the producer passes down an external gas pipe having its lower end dipping into a water seal. Close to the bottom of this pipe there is a branch at right angles, which is made with the object of suddenly changing the direction of the flowing gases, so that dust, or any other extraneous matter carried over from the producer is projected down through the extension of the pipe into the water seal. The branch above referred to is led to the lower portion of the scrubber, where it is sometimes made to dip into water at the bottom of the vessel, to the extent of about $\frac{1}{2}$ in., forming a water seal so as to prevent any of the gases returning to the producer when starting it to work, or during the stand-by periods. This safeguard, however, is more frequently effected by shutting off a valve in the down pipe from the producer when the engine stops running, or during the lighting up periods. Immediately above the water chamber at the bottom of the scrubber is a grating, and above this the vessel is partially filled with coke, which is kept saturated by a spray of water at the top; the gas in passing upwards passes through the wet coke, and so becomes cooled and thoroughly cleansed and leaves the scrubber at the top.

Sometimes a dry sawdust scrubber is fitted to the top of the wet coke scrubber, in which case the spray is brought below it so as to perfectly dry and clean the gas from dust and any small quantity of tar, if present, before being led to the engine. In case of large plants a separate dry scrubber is added. The overflow from the water chamber is led to the outside dust collecting sump, and thus limits the level.

Expansion Box.

The gas, after leaving the scrubber, is led direct to the engine, but on its way is frequently passed through what is termed an expansion box placed close to the cylinder. The object of this is to form a reservoir from which the engine can more readily draw its charge; at the same time it reduces the variation that would otherwise take place during the suction strokes, lengthens the period of the draught through the producer, and makes the action on the fire more regular and uniform.

Tar Extractors.

In the case of fuels containing tar compounds which are not formed into permanent gases in passing through the fire, tar extractors have to be used between the scrubber and the expansion box. These are made sometimes in the form of staggered plates fixed in a box partly filled with water which acts as a washer. In other cases a centrifugal rotating disc or blade is introduced, to which water is admitted which thins the tar and permits it to be thrown off radially by centrifugal action, and

drained into a sump, where it is collected. When this apparatus is employed it is necessary to use an additional sawdust scrubber.

Lighting Up.

For the purpose of lighting up, or for starting the plant after it has been shut down for the night or at week ends, a hand-worked rotary fan is attached to the producer furnace shell so that air can be forced through the system, care being taken to shut off the connection to the scrubbers, and at the same time a connection is made to the atmosphere through an exhaust pipe which is formed by an upward extension of the down gas pipe previously referred to. Close to this pipe is fixed a testing nozzle through which a small quantity of producer gas is allowed to escape; this, when lit, burning with a blue flame tinged with red, indicates that the gas is in a condition for use. When this takes place the exhaust pipe is shut off, connection remade to the scrubber, and the engine is started.

Practically the only parts of a producer plant that are likely to wear out are the fire-brick linings, fire bars, and the evaporators, when these are placed at the top of the producer, but rarely if they are properly designed and due allowance made for expansion and contraction. The cost of renewing the furnace lining can be taken as about £4 10s. for a 100 h.p. plant.

Producer gas plants can be made to use almost any kind of fuel or refuse, such as wood chips mixed with shavings, sawdust, husks of nuts, cotton seed and cake, lignites, peat, and even locomotive smoke-box refuse. A 100 h.p. plant using sawdust as fuel yields about 20 gallons of tar per 60 working hours, and about $3\frac{1}{2}$ to 4 lbs. of sawdust will be consumed per b.h.p. hour.

Whether the plants use anthracite, coke, coal, wood chips, &c., as fuel the chief difference in their construction is in the size of the grate and furnace, charcoal requiring a slight increase as compared with anthracite. Presuming a gas engine has been working with town gas, and is then put to work on anthracite or charcoal, the power obtainable would be reduced by about 10 per cent., while if worked on coke the reduction would be about 15 per cent., and this, of course, is due to the lessened calorific values of the gas produced.

The consumption of fuel in producer gas plants, and which makers would guarantee, can be taken as varying from:

·75 to 1 lb. per b.h.p. for anthracite.
·80 to 1·25 lbs. per b.h.p. for coke.
·85 to 1·5 lbs. per b.h.p. for charcoal.

These quantities are given within limits because they would vary with the calorific value of the fuel, that is to say, the British thermal units that can be got out of it, and also depending on the size of the plant as well as on the construction of the details of the gas engine that affect the economy.

As against these figures the fuel required for steam engines having say 90 per cent. mechanical efficiency, assuming that 1 lb. of coal will evaporate on an average 8 lb. of water under ordinary working conditions, will be as follows :—

TYPE.	Pounds of Water per		Lbs. of Coal per B.H.P. Hour.
	I.H.P. Hour.	B.H.P. Hour.	
Compound surface or jet condensing	13·5	15	1·9
Compound non-condensing	20	22·2	2·78
Non-compound, non-condensing ..	25	27·8	3·48
Do. of moderate powers......	30–35	36·1	4·5
Do. for small h.p.s, say for agricultural purposes	40	44	5·5

The oil consumption for gas engines, an important item, can be taken as ·002 pints per b.h.p. hour, or say 11 gallons per 60 hours for a 100 h.p. plant. All oil used for bearings, which should be fitted with oiling rings, is recoverable and re-used after filtering.

As regards the question of depreciation, maintenance or up-keep charges in connection with producer plants and engines, I estimate as under :—

	Producer, per cent.	Engine, per cent.	Combined Plant per cent.
Depreciation	8	6	6·5
Maintenance	4	3·5	3·6

From inquiries I have made from time to time I have not heard that any plant supplied during recent years has yet been worn out or discarded, so it is impossible to say yet how long such plants will last, but there is no reason that I can see why they should not last as long as steam ones, and with much less expense to keep them in an efficient condition. One firm told me they had a 190 b.h.p. set working night and day for two years.

These plants require very much less attendance than steam ones, permanent stokers being unnecessary (except in large plants). A skilled man, however, should have charge, but to only occasionally look after the plant, particularly at week ends, and to see that the cylinders, piston heads, sparking plugs and valves are kept clean, while an unskilled man can easily take working charge, to stoke the producer, which is very easy, only requiring a bucketful or two of fuel at regular intervals, depending, of course, on the nature of the fuel and the work the engine has to do. Clinkering has to be done only two or three times

a day. The work is light, the plant after starting being automatic, and even with a 150 to 200 h.p. plant the attendant would be free several hours per day.

It is true that some suction plants have been replaced by steam. Not knowing the circumstances I am unable to give the reasons, but in all probability it has been due to the plants having been installed during the early days of the system, when the details were not perfect. In engines working with suction gas, the compression and explosive pressures in the cylinders have to be much higher than when working on town gas, so probably the cranks, crank pins, &c., were originally made too small.

There are, of course, cases where a steam plant would be better than a gas one, such as where heating is required as well as power, or where very large powers are required. However, I know of one installation where a 1,500 h.p. gas engine is working rolling mills, using producer gas made on the Mond system.

I am satisfied that suction gas plants as now made are reliable. They are used in cotton spinning mills and electricity works, where very constant speed is necessary; in the latter case the flywheels are made exceptionally heavy, and so give a very small percentage of fluctuation of speed. To obtain large powers two engines can be placed side by side with the flywheel between them or coupled in tandem, which is cheaper to construct, while either of these arrangements can be doubled by coupling a tandem pair side by side.

Up to the present, satisfactory small and moderate size producers for working gas engines that will burn bituminous coal have not been put on the market, but I know of one firm which has solved the problem, and only a couple of weeks ago started a 50 h.p. plant, which is working satisfactorily. Some little time must, however, elapse before it is ready for putting this before the public.

When large quantities of gas are required for working large power engines, such as 2,000 h.p. and upwards, or for heating and furnace work, then bituminous coal can be used with advantage, as the value of the by-products would practically pay for the cost of working.

The water consumption in these plants is about $1\frac{1}{2}$ to $1\frac{3}{4}$ gallons per b.h.p. hour, viz., 15 to $17\frac{1}{2}$ lbs., which covers both the furnace and the scrubbers. These figures can be compared with the quantity of water required for steam plants, to which of course, is to be added in the case of condensing engines, the very large quantity required for condensing purposes, which for jet condensing is about 32 times the quantity of steam used, and for surface condensing about 30 times. But in properly designed plants a great portion of this can be used over again.

The suction gas producer system has the great advantage that it is self-adjusting, by reason of the engine drawing or sucking its charge only as it is needed, and directly in the proportion to the demand; for example, when the load on the engine varies and varying impulses or explosions are required, the production of gas is increased or diminished in direct ratio, while when the engine stops production ceases, and this leads to the statement that the stand-by losses during the time the engine is not at work, the consumption of fuel that would be burning to waste, is extremely small, say 3 lbs. per hour for a 100 h.p. plant or 36 lbs. when shut down at night for 12 hours, while the corresponding waste in a steam plant would probably be 8 times as much.

The thermal efficiency of suction gas plants is much higher than in the case of steam, as 24 to 25 per cent. of the energy in the fuel is available at the circumference of the driving pulley, while in steam it is only 9 to 10 per cent.

Thus a firm in the north told me that they had a 100 h.p. plant which had been running for three years, giving every satisfaction; the furnace lining had not been renewed, but a few fire-bricks had been replaced. The plant worked 56 hours per week, and they consumed three tons of coke and half a ton of anthracite, which included stand-by losses, while previously they used 16 tons of coal. Another firm have two 350 b.h.p. sets worked in tandem; they work 56½ hours per week and use 4 tons 19 cwts. of good gas coke, which works out to the very low figure of ·85 lbs. per b.h.p. hour.

The cost of working gas engines with suction gas producers is very low, in fact, it is one of the most economical systems; but when large powers are required, no doubt, high class triple expansion steam surface condensing engines would run them fairly close; but then they bring in their train a multiplicity of auxiliary appliances, such as economisers, superheaters, mechanical stokers, condensing plant, water cooling towers, feed pumps, oil separators and high class attendants. Unless current is procurable at about ½d. per unit, electricity cannot successfully compete unless the power required is at very intermittent and lengthened intervals.

The chief advantages of such gas plants as compared with steam, outside the fuel consideration, may be summarised as follows :—

No expensive boilers required, with their necessary costly foundations, flues and chimneys.

No smoke. No danger from fire.

Occupy much less space than steam plants, and may be taken as being 50 per cent. less.

No risks of explosion and great safety; there being no outlet for the gas except to the engine itself.

Less storage space for fuel, one-third to one-half.

Less water required per b.h.p. hour, and when the supply has been once adjusted very little attention is necessary.

Less labour and less expensive working, one intelligent workman being easily able to look after, say, a 300 h.p. installation, the fuel having to be put into the producer at regular and fairly lengthened intervals, say one or two hours for coke, but less for charcoal, and does not want constant supervision.

No fuel burnt to waste, as in the escaping gases of combustion up a chimney shaft in steam plants, and very low stand-by losses when the plant is not at work.

The plant working under suction, there is no waste by leakage or from any other cause, such as takes place through the safety valves of boilers, drain cocks and stuffing boxes of steam cylinders, or from the condensation of steam in steam pipes; whereas in the case of suction gas plants the greater the radiation the better, as the colder the gas on reaching the engine the denser it is, and a greater weight of charge is taken in the cylinder each suction stroke, which is a desideratum.

The producers do not require costly foundations.

The plant can be started very quickly, even when cold, say in 30 to 40 minutes for a large plant, and only requiring a few minutes after the plant is shut down, say, from 6 p.m. to 6 a.m.

In the face of the present and probable future labour troubles it is particularly necessary to study the questions of cost of motive power, fuel, and labour, and the adoption of the system I have described would prove of material benefit to the users. Good producer gas can be made from wood refuse, and of the plants of two firms brought under my notice, one burns only chips and sawdust-wood, blocks or firewood not being necessary, and the generator needs charging only every 1½ to 2 hours. The other, a 50 h.p. plant, burns sawdust, waste wood and bark, and has not used an ounce of coal the last year, 5 to 10 per cent. more power is got than when burning anthracite. It may be taken that 2½ to 3½ lbs. of wood refuse is required per b.h.p. per hour.

Smoke Abatement in Germany.

By Dr. Kobbert
(Manager of the Gasworks at Königsberg).

Abstract.

The first real progress in the campaign against black smoke in Germany dates from the promulgation of the Prussian State regulations on the subject. These were copied by all the other States of the German Empire. The next step in advance was due to the interest aroused by Dr. Ascher's investigation, in 1905, in Königsberg upon the relation between the purity of the air supply and diseases of the throat and lungs. This investigation led to a claim that the purity of the air supply ought to be of equal importance to that of water supply and drainage, and to the founding in 1906 in Königsberg of a "Kommission zur Bekämpfung des Rauches," which publishes annual reports upon the subject of Smoke Abatement.

The following principles have been recognised as governing all attempts to minimise smoke in Germany:—Chemical and calorific valuation of the fuel ought to precede its selection for any purpose. The type of furnace and method of firing adopted ought to be chosen in relation to the cheapest and most easily transported coal available in the locality of the works where it is to be used. Having selected a grate and fuel suited to one another, the question of the best method of supplying and regulating the primary and secondary air must be considered.

For this purpose gas-testing apparatus must be installed, and, if possible, a continuous recording apparatus to show the amount of smoke emission. The importance of employing a thoroughly competent fireman is next touched upon, and the author states that automatic apparatus for regulating the secondary air supply must be installed when such a man is not available. The German makers of some of these are named, also the manufacturers of apparatus for heating the secondary air supply. A third group of smoke abatement appliances are designed to overcome the difficulties of an irregular air supply, by regulation of the feed of fuel, either down an inclined grate, or by mechanical stokers. The German makers of this class of apparatus are then named.

The difficulty of avoiding smoke with household fires and with bakers' ovens is next dealt with, and it is stated that these together are the "Starksten Rauchbilderen in der Stadten." It has been recognised, however, in Germany, that

there comes a point when the attempt to obtain the smokeless combustion of bituminous fuel becomes unprofitable, and that the only real solution of the bituminous smoke problem is to forbid the use of bituminous fuel in "gewerblichen industriellen und sonstigen Feuerungen." This opinion favours the substitution of anthracite, coke, and oil for bituminous fuel, and, if the latter must be employed, the combustion of the volatile constituents of the coal separate from the solid. The slow-combustion stove burning coke, or the "Kacheloven" burning coal, are both smokeless methods of heating houses. Hot-water heating is also being widely employed in Germany for dwelling rooms and flats. The use of oil for heating purposes is extending.

As regards the manufacture of producer gas and water gas from coke, or of illuminating gas from bituminous coal, these are all extending rapidly, and it is interesting to note that coke-oven gas is now being delivered by pipes, in many of the smaller German towns and villages, for heating and lighting purposes.

The beehive type of coke-oven is quite discarded for the more modern Koppers type of oven, with recovery of the by-products and sulphate of ammonia. The author concludes that gaseous fuel is, without doubt, the most practicable and cheapest agent for obtaining heat without smoke at the present time.

J. B. C. Kershaw, F.I.C., F.S.S.

Hand-Fired Boilers, &c.

By J. Stothart Pearson, M.I.Mar.E.
(Consulting Engineer).

The presence of this influential gathering, representing the most important commercial centres in Great Britain, is sufficient proof of the interest now aroused in the subject of smoke prevention as well as in the various methods suggested to remove, what I feel justified in designating, a national disgrace.

It will indeed be a pity if, in the present day light of science and practical progress in sanitary affairs, the industries of this country cannot be conducted in a profitable manner without rendering the atmosphere impure and unhealthy, and without continuing to mar the national beauty of our land.

Before we institute drastic penalties against steam-users and industrial concerns generally for causing an undue amount of smoke to issue from the furnaces in their works, much may be accomplished (with the requisite legal aid in the meantime) in the direction of removing some of the more immediate causes of the smoke nuisance. It appears to be a somewhat indirect method to strike at the effect rather than to devote practical attention to the removal of the cause in the first instance.

The principal causes of excessive smoke from factory chimneys may be summed up in the words of the title of this paper, *i.e.*, "The Hand-Firing of Boilers, the Training and Qualification of Stokers, and the Over-loading of Steam-Boiler Plant."

It may be argued that to institute heavy penalties for the emission of smoke will have the effect of reaching and remedying the causes sooner or later; but it must be remembered that proprietors upon whom the penalties fall not only recognise that smoke is wasted fuel, but are generally desirous to prevent this waste, and have no wish to breathe an impure, smoke-laden atmosphere or inflict such conditions upon others. Also that, in many instances, proprietors have gone to enormous outlay in the endeavour to remove the cause of smoke, and that those of their number who have failed in their efforts, or who have not yet made the attempt, will all be glad to receive really practical assistance in this direction. So that, rather than unduly antagonise them by inflicting heavy penalties, our efforts should be made in such a direction as will result in securing their support.

A large majority of steam boilers are hand-fired, so we must endeavour to deal with this condition.

According to my experience, whether a boiler is hand-fired or mechanically stoked the chief cause for the production of smoke lies in the fireman, and so long as proprietors are permitted or obliged to employ unskilled labourers to take charge of their furnaces, the smoke nuisance and coal-waste will continue in spite of penalties.

When we consider that the fuel bill in any large concern is often the heaviest item in the working expense account, and the one item more than all the others in which it is known and admitted that great waste and monetary loss is continually going on, surely it is necessary for every proprietor to look seriously into this question—as many have already done to their profit. Here, however, the proprietor is confronted with a serious difficulty. Very few trained and qualified firemen are obtainable, and in the majority of instances he has no alternative but to take what he can get in the way of firemen so long as they are steady and can be depended upon to be regularly at their posts.

It would therefore appear that if the smoke abatement movement can be the means of bringing about such legislation and improvement, whereby proprietors may be supplied with trained and qualified firemen, who understand the value of coal and its use in a practical and efficient manner, so as to extract from it the highest possible heating power—the regulating of furnace temperature, the conditions of combustion, admission of air, the heating value of various qualities of coal, and so forth—then the annual saving will be very considerable.

Now how is this desirable condition to be brought about? Like all reforms, it is certain to meet with opposition to commence with, especially on the part of firemen; hence it will be necessary to invoke the aid of the law.

I would propose that an Act of Parliament should stipulate that schools shall be established or classes in our technical schools, where firemen shall be taught the chemical process of combustion and the various technical and practical points with regard to boiler management. Also that arrangements shall be made whereby municipal authorities will allow candidates to visit electric generating stations, pumping stations, &c., at stated times in the company of an inspector, so that they may receive practical demonstrations in firing, and themselves give practical demonstrations of their knowledge and efficiency.

It would be necessary to provide a hand-fired boiler for this purpose. The course of training should be of sufficient duration or a sufficient number of attendances made by each candidate. The candidates should pass a verbal (or written) also practical examination, and obtain a certificate of competency. Every person in charge of the furnaces of steam boilers or other industrial furnaces where quantities of coal are consumed should hold a certificate of competency.

The Board of Trade does not permit a steamer to sail without certain certificated engineers on board. Why not certificated firemen? What can a certified engineer do without the motive power to drive the engines? The chief economy in sailing a ship cannot be effected in the engine room, but in the stokehold. If the status of firemen were more elevated—owing to compulsory training and qualification—we should have a superior class of men in this department. The fuel bill would be reduced, the labour would be very much lighter, and the all round conditions at sea much improved. I would propose that a given time be fixed after which all firemen must be certificated.

I have in mind two large steamers, which when new were noted for the dense volumes of black smoke emitted from their funnels and their high consumption of coal. After a time a system was adopted whereby the stokeholds are connected by electric signals, and all practically under the control of one engineer on watch.

Exact to time, each stokehold, upon given signal, either "fires" or "rakes" alternately, and that according to a prescribed method.

This system has resulted in the prevention of smoke, produced more steam, increased the speed of the vessels, and effected a very considerable saving in coal. Furthermore, the firemen have an easy time of it, declaring these vessels to be amongst "the easiest worked jobs they can get."

Another instance within the writer's experience (reverting to land work), and sighting the work of two firemen with the same boiler, in good all round condition and working under its normal load. Thomas H—— was continually ram, ram, ramming at the furnaces. He thought it quite the proper thing to keep the chimney smoking heavily. He worked hard at his fires, and had little time for anything else. The steam pressure was not steady. In course of time John C—— was appointed in charge of this boiler, after which, and for over a year, by the writer's observation, the works might have been stopped for what amount of smoke passed from that chimney. He fired according to Watt's plan, kept a steady steam pressure, and saved coal. The job was play-work to him. The load upon that boiler was exactly the same under both men.

Still another instance. An elderly fireman at a hydraulic pumping station belonging to a railway company having three Cornish boilers working under moderate but variable load. This man boasted that he had fired for over thirty-five years, and could guarantee to burn more coal in those three furnaces than any other man in the company's employ, and in the ignorant belief that his ability to do this proved him to be a qualified fireman who had nothing more to learn. Moreover, he could and did burn more coal than anyone else—very much more—

and had been doing so for thirty-five years, to the pollution of the atmosphere and the company's loss. To the writer's certain knowledge it would have paid that company handsomely to have given the man his wages each week to stay away and leave his employers' coal alone.

Marine firemen are, as a rule, the most wasteful of any. They appear to know nothing beyond shovelling as much coal into the furnace as can be got in at one time, and shortly afterwards to "smash" at it with a heavy rake to the utmost limit of their strength!

I recite these instances by way of illustration and in support of my plea for trained and qualified firemen. It is appalling to think of how valuable fuel is permitted to be wasted, with all its concomitant evil results, year after year, while the amount of increased wages paid to qualified men would be a mere tithe of the saving effected.

I now come to the question of the normal load and the overloading of steam-boiler plant, by which I wish to infer the working of a boiler up to its normal capacity for evaporation and not beyond it.

With everything in a satisfactory condition, such as suitable grate area, sufficient draught, easily regulated dampers, good coal, &c.; it is quite possible to fire a boiler by hand, with a fairly high degree of efficiency, practically smokelessly, and at the same time maintain its normal evaporative load.

In this connection I would suggest that a department should be instituted having qualified inspectors, whose duty it would be to make an examination of the following conditions, and report to the department:—

(*a*) The condition of the boiler seating and if there is any "short-circuiting" of the gases.
(*b*) The arrangement and area of the flues and passages.
(*c*) The area of the furnaces and fire-bars.
(*d*) The pressure of draught by U water gauge.
(*e*) The quality of the fuel used (calorific value where possible).
(*f*) The nature and temperature of the feed-water, also the point of admission.
(*g*) The area of the heating surface.
(*h*) If there is any leakage of air through the brickwork.
(*i*) The length and diameter of the boiler, &c.

And upon this report the department should compute the normal evaporative capacity of the boiler, and issue a certificate allowing the boiler to be worked up to, say, 90 per cent. of that computed normal capacity per hour, and not beyond it.

This would provide a safeguard against forced firing. The quantity of feed-water entering the boiler should be registered through a feed-water meter.

Boiler insurance companies do not trouble beyond the strength and condition of the metal, the general conditions, and the working pressure. If it is necessary to stipulate the pressure for safe working, it is quite as necessary to stipulate the evaporative output of power per hour in order to prevent smoke and forced firing.

It often happens that some, or several, of the foregoing conditions are defective, and in which case it is impossible to obtain what should be the normal output of power without unduly forcing the fires. I would therefore "grade" the stipulated output of power allowed according to these conditions. Besides, a good fireman will not long remain in charge of a boiler working under defective conditions, with the result that someone has to be found with more strength than intelligence to do the work, and the smoke output is correspondingly increased.

In order to surmount some of these defects forced draught is frequently resorted to. To give one instance in may own experience. A Cornish boiler had been fitted with forced draught for twelve years, during the whole of which, although it had been impossible to generate more than about 40 per cent. of the normal power of the boiler, it had never been discovered that the area of the passage into a good chimney had for some absurd reason been restricted to 14 in. square, and had two right-angled turns in its course; also that instead of the gases passing from the fire-tube to the bottom flue and thence to the side flues, the reverse order had been adopted. Yet no boiler inspector had thought it worth while to point out these defects to the proprietor.

Another instance in which three Lancashire boilers, 8 ft. 6 in. by 30 ft., working at a colliery under 140 lbs. pressure, were found to be "short-circuited," and for 13 ft. from the front ends backwards were entirely unsupported. This was caused for the want of sufficient foundations, the boilers having been carelessly erected upon an old pit-heap and the seating blocks having fallen away. The result of this condition was that the requisite output of power could not be maintained without unduly forcing the fires, and the output of smoke was as might be expected.

I therefore contend that it is high time to urge that a special department shall be instituted, having competent inspectors under whose supervision all steam-boiler plant shall come.

It may be that existing sanitary laws already give sufficient power to municipal and county authorities to carry out this work within their respective areas. If this should be the case it would greatly simplify matters, provided such authorities were obliged to take up this work of inspection and certification and would lose no time in setting about it.

The Smoke Evil.

Is Further Legislation Necessary? If so, What should be its Aims?

By Joseph Hurst

(Barrister-at-Law).

That the emission of coal smoke in such quantities as to be a nuisance is an evil does not admit of debate, or even of doubt. Questions remain as to the best methods for procuring the suppression of the nuisance. That such suppression is in the interests of health, of property of every kind, and of economical use of coal, has long ago been established. That such suppression should be assisted and secured by legislative enactment has for a long period of time been recognised. Accordingly from time to time Acts of Parliament with general or local application have been passed with this view. The questions to which I have undertaken to invite attention at this Conference are: Is further legislation necessary? If so, what should should be its aims?

For a useful discussion of these questions it is essential to recollect the present position of legislation and of legal decisions founded upon it.

The *Public Health Act*, 1875, enacts that any fireplace or furnace which does not, as far as practicable, consume the smoke arising from it, and which is used (speaking generally) for trade purposes shall be deemed to be a nuisance. (*Sec.* 91, *Sub-sec.* 7.) And a similar provision is enacted with respect to any chimney (not being the chimney of a private dwelling-house) which sends forth *black* smoke in such quantity as to be a nuisance (*ib. Sub-sec.* 8). But a proviso to *Section* 91, which has been decided to be applicable to *Sub-section* 7 only, causes proceedings under this sub-section to involve the discussion and decision of issues of an engineering and technical character from which proceedings under *Sub-section* 8 are free (*Weekes v. King* 53 *L.T. N.S.* 51, 49 *J.P.* 709; see also *exp. Schofield* (1891) 2 *Q.B.* 428, 60 *L.J. M.C.* 157, 64 *L.T. N.S.* 780, 56 *J.P.* 4). Under sub-section 8 only the simpler question of fact is involved :—Has black smoke issued in such quantity as to be a nuisance? Under similar words in the *Public Health* (*London*)

Act, 1891, it has been held that a magistrate before whom proceedings came would be justified in finding that a nuisance existed although there was no evidence that any particular person or property was injuriously affected where the smoke issued from a chimney several times a day for a series of days for periods varying from a few minutes to upwards of an hour. (*South London Electric Supply Corporation v. Perrin* (1901), 2 *K.B.* 186.) And it has been held under this last-named Act (which in *Sec.* 261, *Sub-sec. B* contains the same words as are to be found in the *Public Health Act*, 1875, *Sec.* 91, *Sub-sec.* 8) that the smoke complained of need not be injurious to health in order to be a nuisance (*Gaskell v. Bayley* 30 *L.T. N.S.* 316, 38 *J.P.* 293).

The local authorities acting either under the *Public Health Act*, 1875, or under the *Public Health* (*London*) *Act*, 1891, are required to enforce the above law by appointment of inspectors, by inspection by them and otherwise. In case of default by authorities acting under the Act of 1875 the Local Government Board may act. And in the case of Authorities who act under the Act of 1891, if they make default, the London County Council may act (except within the jurisdiction of the Corporation of London) as well as the Local Government Board.

So much for the law as it stands at present.

It will be seen that issue of grit from chimneys is not dealt with. But as this has become a serious nuisance, as the result of artificial draught in furnaces, and is capable of remedy, it will, I think, be generally agreed that an addition should, on a convenient opportunity, be made to existing public health legislation dealing with the emission of grit from furnace chimneys. Such an addition has been secured by the Bradford Corporation in a local Act obtained by them in 1910.

A far-reaching alteration of existing legislation has, however, been suggested in important quarters, and has received considerable support. I mean the suggested deletion of the word "black" in *Section* 91, *Sub-sec.* 8 of the *Public Health Act*, 1875, and in *Section* 24 (*b*) of the *Public Health* (*London*) *Act*, 1891. The language of these enactments would then be :—

"Any chimney (not being the chimney of a private dwelling-house) sending forth *smoke* in such quantity as to be a nuisance shall be deemed to be a nuisance," &c.

This proposal was in 1910 submitted in a Bill promoted in Parliament by the London County Council for this and other purposes. But the Committee to which it was referred did not accept it. On a subsequent deputation to the Local Government Board, organised by the Smoke Abatement League, it appeared that the President (Mr. John Burns) who accorded the deputation a most sympathetic reception, might personally, at least, be in favour of the alteration.

I beg, however, with the greatest respect, to submit to your

consideration opposing views. I think the deletion of the word "black" would tend to retard the prevention of the smoke evil, as that deletion would, as I suggest, take away some of the legal sanctions already secured in the interests of public health. In other words, the sections of the Acts of Parliament as they now stand containing the word "black" are not only well known, but have been the subjects of many decisions by the Courts. Those decisions establish that the issue of black smoke in large quantities is a nuisance *per se*. No such tests and considerations, and no such evidence is requisite as must ordinarily be applied, and laid before the Courts in cases where complaint is made of nuisance. Once delete the word "black" from the sections under consideration, and in a summary proceeding before a stipendiary magistrate, or before a bench of lay justices, such questions will have to be debated and determined and illustrated, or the reverse, by technical, and, probably, contradictory evidence, as are referred to by the late Lord Chief Baron Pollock in the case of *Bamford v. Turnley* (31 *L.J. Q.B.* 292). There, dealing with an action for alleged nuisance, he said :—

> "The question so entirely depends on the surrounding circumstances, the place where, the time when, the alleged nuisance, what, the mode of committing it, how, and the duration of it, whether temporary or permanent, occassional or continual, as to make it impossible to lay down any rule of law applicable to every case, and which will be also useful in assisting a jury to come to a satisfactory conclusion. It must at all times be a question of fact with reference to all the circumstances of the case. Most certainly, in my judgment, it cannot be laid down as a legal proposition, or doctrine, that anything which, under any circumstances, lessens the comfort or endangers the health or safety of a neighbour, must necessarily be an objectionable nuisance. That may be a nuisance in Grosvenor Square which would be none in Smithfield Market. That may be a nuisance at mid-day which would not be a nuisance at midnight. That may be a nuisance which is permanent and continual, which would be no nuisance if temporary or occasional only. A clock striking the hour, or a bell ringing for some domestic purpose may be a nuisance if unreasonably loud and discordant, of which the jury alone must judge ; but although not unreasonably loud, if the owner, from some whim, or caprice, made the clock strike the hour every ten minutes, or the bell ring continually, I think a jury would be justified in considering it to be a very great nuisance. In general a kitchen chimney, suitable to the establishment to which it belonged, could not be deemed a nuisance, but if built in an incon-

venient place or manner, on purpose to annoy the neighbours, it might very properly be treated as one.

"The compromises that belong to social life, and upon which the peace and comfort of it mainly depend, will furnish an indefinite number of examples in which some apparent natural right is invaded, or some enjoyment abridged, to provide for the more general convenience or necessities of the whole community."

As legislation and decisions now stand, no such considerations have to be ventilated before tribunals generally dealing with subjects of a very different character. As I have shown, no proof now is needed that health or property is affected or liable to be affected. A discussion before a court of summary jurisdiction where the Health Authority is now often represented only by its Sanitary Officer, as to whether the ordinary comfort of human existence in a particular district has been or is liable to be interfered with by the issue of smoke, would be properly excluded as foreign to the occasion. As the law stands at present, proof of the issue of black smoke for a substantial period, at frequent intervals, establishes a case of nuisance without more, and that, because the legislature and the Courts have attached that character to black smoke so issued. With the word "black" gone, the blackness or density, or quantity of the smoke, would be only one element in the consideration of the matter, whilst for its determination all the other elements which, as I have shown above, go to constitute a nuisance, would have to be proved and discussed. And this, too, where the Health Authority may not have intervened at all even by a Sanitary Officer, but where the summary proceedings may have been instituted, by an aggrieved person of small means!

For these and other reasons which will readily occur to many, I submit that the deletion of the word "black" would make practically impossible the abatement by the present summary procedure of "smoke in such quantity as to be a nuisance."

It is true that, technically, the use of the word "black" is inaccurate, for we are assured that there is no such shade as black, except perhaps, as some say, in a few feathers in the tail of a starling. It is true also that the appearance of smoke emitted from a chimney is, to a considerable extent, varied by the character of the prevailing atmosphere, by the presence of sunlight, or by its absence, and by the nature of the background created by clouds. But if the word is regarded by magistrates in the popular sense in which the legislature has for public health purposes used it, I would submit that little difficulty will be found by tribunals actuated by a *bona-fide* desire to carry out public health legislation, using popular phraseology, as applied to the comparatively simple issue has black smoke been sent forth?

There is, however, another consideration which should not

be forgotten. There is much smoke that is not at all black, on the contrary, that is almost white, or quite yellow, that is at least as much within the mischief of public health legislation as smoke described as "black." I would, therefore, suggest that in any amendment of statute law on this subject it would be desirable to add to the present word "black" the words "or dense."

At present, at any rate, it would appear that the absence of all smoke from factory chimneys is, in many cases, an unattainable desire, but if laws of sanitation forbidding the issue of black, dense smoke in such quantity as to be a nuisance were properly enforced, the protections aimed at would probably be afforded.

Substantially for the reasons suggested above, I submit that the "Smoke Abatement Act, 1912," proposed by the Smoke Abatement League, would increase difficulties in the way of procuring smoke abatement. The Bill proposed would create new authorities, new procedure, new offences, new possible defences on the part of offenders, greatly increased expense, all in addition to the existing authorities, procedure offences, defences, and expense contemplated and provided for by existing legislation.

My submission is that the efforts of those interested in these important endeavours towards health and cleanliness should be directed to a simplification and enforcement of existing law, rather than to untried attempts, possibly involving new difficulties.

Proposed Legislation.

By Principal J. W. Graham
(President, Smoke Abatement League of Great Britain).

When the Smoke Abatement League of Great Britain was founded at Sheffield, after the Conference there in 1909, it was felt that the best service it could perform was in the region of legislation. The failure of the provisions of the Public Health Act of 1875 over the whole of England, with the exception of London and some seven large towns, and their very partial success even there, was plain. This failure of the public to achieve freedom from a widespread source of loss and lessened vitality appears to be due to the following removabl ecauses :—(1) The phraseology of the Act ; (2) the smallness of the fines ; (3) the apathy of the local authorities ; (4) the absence of any method of bringing scientific knowledge wielded by an impartial authority to bear upon negligent manufacturers ; (5) the absence of a complete and immediate cure for domestic smoke.

With regard to (1). A universal legal prohibition of all manufacturing smoke occurs in no Act, and at present can usefully occur in none, however much we earnestly desire completely clean air. There is the difficulty of the high carbon steel furnaces, in which it is still an arguable point whether smoke is an essential or not ; and there are pottery furnaces, beehive coke ovens, and puddling furnaces in existence, which at present must make smoke. These have hitherto been exempt from all legislation under a clause which says that smoke is only to be avoided as far as practicable in the carrying on of a business. These words occur in every Act except the Act in force in Nottingham, a town which contains none of these difficult trades. Immediate drastic legislation against these manufactures could not be passed, might be unjust to them, and would, if passed, remain a dead letter. On the other hand, these trades produce the worst smoke centres in England. Exemptions are habitually pleaded much in excess of what is scientifically or mechanically necessary ; and in a town like Leeds or Warrington, for instance, the immunity of the iron works paralyses local effort against boilers and smoky chimneys generally.

We shall do little good unless we can make some impression on places like Sheffield and Middlesbrough. We desire, that is, to create some active and well equipped power, which shall keep the plea for immunity within the narrowest limits consistent with justice. It is admitted that, by one means or another, boilers can be made smokeless, and that in the majority of cases, and in the long run, capital investment in this direction will be remunerative. It is admitted that, by gas-firing, or by sending the gases in succession through other furnaces, the potteries may be redeemed from their present horrible condition

It is further admitted that puddling has, in many instances, been done successfully by gas, and that low-grade steels can be re-heated in that or other ways. Proposals are in the air, and claim practical achievement, for doing the same for high-class steels, a claim, however, which is still denied by some. Reckless stoking is common in all these trades.

The difference of opinion among experts on this point is well illustrated in a prolonged discussion which took place in January and February, 1912, in the *Sheffield Daily Telegraph*.

Professor Arnold, of the Metallurgical Department of the University of Sheffield, refuses, not without heat and the smoke of conflict, to grant that high-grade steels can possibly be manufactured without surrounding them with a smoky atmosphere. On the other hand, there is experienced testimony from Coatbridge, near Glasgow, saying that it is being done there in two iron and steel works with smokelessness and economy. A representative of Mr. Frederick Siemens asserts that numerous firms in Sheffield use their furnaces, which are practically smokeless, for high-class steel. Instances to the same effect are brought from Remscheid, in Germany, by Mr. Kershaw; and at our last Conference, Mr. Macaulay testified to having seen it done at Liège. Mr. Victor Stobie, of Sheffield, claims to have re-heated high carbon steel without producing one-tenth of the usual quantity of smoke, and with almost automatic certainty. Mr. Scott Anderson, a Sheffield consulting engineer, also denies that black smoke is essential, and is supported by steel experts of high standing in the making of any grade of steel. Another young manufacturer refuses to accept the reactionary view as final, and instances the process in use in Sweden of rolling the steel in molten slag beforehand, which protects it from oxidisation. A correspondent, "V. R. C.," recommends the Galloway-Hill patent furnace as achieving all that Mr. Stobie speaks of. Again, whilst Professor Arnold says that he keeps a smoky furnace for annealing in his laboratory, Mr. Stobie says that the gas-fired furnaces used by Krupp, Lindenburg, and others in Germany, are used entirely for annealing, in furnaces which do not have to be opened until the treatment of the steel is finished. This makes the preservation of the proper atmosphere round the steel a simple matter, and everything in annealing favours producer gas-firing.

Under these circumstances our proposal is to permit exemptions from the absolute rule to be made to particular chimneys for a limited period by the Smoke Department, which we propose to have created in the Local Government Board. We propose that these should be renewable for two years, and that the power of exemption shall, for the present, only be granted for ten years in all. As the end of that time approaches it will be easier to see what to do next. The skilled officials of the

Board would be able to explain to any maker of smoke what means there were in the market for obviating the nuisance, and would be able to grant him the necessary time to alter his plant. He would shortly become the friendly adviser which the alkali inspectors now are to the trade who fought so strongly against their appointment. To offer the decision of an expert department, given out of full knowledge, and without legal costs, is much better than to ask Corporations to fight each case before an ordinary judge or magistrate, spending the money of the ratepayer on costly expert advice, and often leading a bewildered court to a haphazard conclusion. Our policy, then, is to bring reason, skill, and independent pressure to bear upon the manufactures, without upsetting his business.

No doubt the decisions of the Board would shortly fall into a routine of procedure, and each furnace of a well-known type would give but little trouble to the Board in deciding. At the same time, it seems better to have the exemption granted to the individual furnace rather than to specify in the Bill any types of furnace, using such words as "re-heating," "rolling," "puddling," and so forth. There has already been one serious lawsuit as to the meaning of the word "puddling," and one can conceive of many technical varieties of name on which defaulters might escape or cause costly litigation. It is, moreover, proposed that the cost of exemption shall be borne by those exempted, and this could not take place unless each certificate had to be paid for. You could not levy a tax through the country upon a particular type of furnace, unnamed and unclassified. Moreover, it is extremely desirable to give the Board unhampered powers, which would be inevitably hindered one one side or another by the insertion of a schedule in the Bill stating what furnaces they might and what they might not exempt.

This legislation by means of administrative order is strictly according to precedent. It is used in the Alkali Acts and in the Pollution of Rivers, and must appeal to everyone as the best way to deal with a nuisance which is entrenched in the habits of the people and supported by vested interests. We hope that before the ten years have elapsed the progress of invention and of public spirit together will enable us to see the end even of this, the most difficult of our obstacles.

The other problem before legislators is whether any means should be provided for protecting offenders in cases of accidental or inadvertent smoke making, or against irritating prosecutions where the smoke is trifling. To meet this latter criticism Parliament has introduced the word "black" as a necessary quality of smoke liable to prosecution. This has proved to be a fatal flaw. No smoke is strictly black; brown and yellow smoke is equally objectionable. There is, and there can be, no adequate measure of the colour of smoke, inasmuch as smoke

from a narrow chimney shows light through it more than the same quality and quantity of smoke from a broad chimney. The conditions of light at the time also enter into the question and bewilder the observer. We have, therefore, left the word "black" out of our Bill, but have left in the words "in such quantity as to be a nuisance, inconvenience, or annoyance." This, we think, is the right test to apply. We have carefully abstained from words in the draft which authorise excuses through forgetfulness, absence of the firemen on other jobs, accidental breakdowns, change in the quality of coal, and all the multitudinous pleas which human nature can suggest. The course of the prosecution is generally difficult enough without adding in this way to its handicap. It may safely be said that unavoidable accidents, such as temporary breakdowns, will receive full consideration, first from the inspector, secondly from the Sanitary Committee, through whom the prosecutions will generally go, and finally from a sympathetic magistrate on the Bench. As with countless other regulations in the public interest, with everything, in fact, which can be prosecuted as a nuisance, from the extinction of a bicycle lamp upwards, the responsibility for keeping the regulation must lie with the individual. There is no place for excuses in the present law and it would be suicidal for us to put it in. We have taken care to extend smoke to include mineral grit, such as is common from some of the cheaper coals in Yorkshire.

(2) The fines are at present inoperative. The nuisance of having to attend the Court is the principal punishment now felt by manufacturers, to whom a fine of a few shillings or a few pounds is not to be weighed in the balance against the first cost and the trouble of avoiding smoke. It is felt that this is peculiarly a case where an isolated offence should not be heavily punished, but a persistent habit of offending should. We have, therefore, put the penalty for the first offence between £5 and £1, for the second offence between £10 and £5, and the fine may (not must) double on successive convictions within an interval of two years. Localities are empowered to deal with nuisances which occur outside their boundaries.

(3) By way of minimising undue local influence, and establishing an authority which will find it difficult totally to neglect its duties, we propose to divide the country into large districts, each managed by an *ad hoc* authority, composed of members of the local sanitary authorities within its borders, with provisions for the co-optation of those who have specially studied the question. In order to meet the case of the few localities at present doing their duty, we propose to exempt them from the operation of this clause after inquiry by the Local Government Board. It is remarkable that this proposal, which formed an important part of the memorial of 1910 to Mr. John Burns, on which our present Bill is based, received in that form the

approval of no fewer than twenty-seven municipalities, whose operations are directly affected by it. The London County Council is, of course, not to be interfered with in the excellent smoke prevention work it already does.

(4) The character of smoke inspection is to be revolutionised; that is not too strong a word. Well-trained scientific men, who can speak on a footing of social and intellectual equality with any manufacturer, and whose liberal salaries will be independent of local favour, are to oversee and, if necessary, supplement the work of the local authorities and their inspectors. These men also, for the future, are to be men having some technical knowledge of the furnaces they inspect. We believe that this reinforcement of brains and independence to the forces of the public will, more than anything else in the Bill, conduce to the purification of the air of the British Isles; and we anticipate that these inspectors will come to be regarded with the same friendliness with which school inspectors and alkali inspectors are regarded by those among the inspected who desire to do right.

(5) On domestic smoke we attempt no legislation.

Finally, we guard against any progressive towns, such as Bradford, Glasgow, or Nottingham, feeling that their present Acts are more advanced than this, by making these provisions an addition to, and not a repeal of, regulations which now exist.

There is a further important and comprehensive clause, not as yet part of the Bill, nor considered by the Committee of our League, which we wish to lay before you. It places boilers and their firemen under licence for efficiency, approves and condemns boilers, flues, and furnaces, forbids all forcing, and imposes a technical qualification and attendance at classes upon firemen. Introduced in a properly gradual way, we feel that these penetrating proposals would grapple with the evil at its source, and be a thorough cure for most manufacturing smoke. But they would cost much, and would disturb many dovecotes.

The function of legislation is to put an effective point upon the best opinion in the country; to support the helpless or timid individual in his struggle against, or his suffering under, strongly organised interests; not to go ahead of public opinion, nor lay down binding rules which are not much better than pious aspirations; but to put such compulsion as is practicable upon recognised public evils. Surely public opinion is strongly against being dirtied by coal smoke. The people give a universal sigh, but feel helpless. We who attempt reform are surrounded by a mixture of general good-will and patient resignation. Our duty, then, is to give shape to this silent revolt, such shape as shall minimise hardship to the traditional makers of smoke, but shall require that good citizenship from all which men of good-will already practise of themselves.

The Law in Other Countries.

By Julian S. Corbett, LL.M., F.S.A.
(Barrister-at-Law).

In 1905 the Foreign Office, at the instance of the Coal Smoke Abatement Society, collected and issued a series of reports on smoke legislation abroad, and considerable new light was thrown on the possibilities of the question.

From a study of these reports it would appear that, bad as we are, we stand far ahead of the majority of foreign countries. In most of them no legislation exists at all. In France, for instance, no general law has been adopted, while all the old attempts to stop smoke pollution in Paris by police "ordonnance" failed against passive resistance. The latest one appears to have fared no better. It was of a most modest character, for it went no further than to forbid the "prolonged emission of thick black smoke" (*interdit de produire une fumée noire épaisse et prolongée*), but even this appears to be little better than a dead letter. Germany, too, has shrunk from making any general law, and does not even venture so far as France in the Paris ordonnance. The German Government goes no further than to order that "care should be taken *in all works under State control,* that the emission of *black, thick and continuous smoke* be avoided, in the first instance, by expert management of fires, proper supervision of firemen, and careful selection of fuel."

Thus we see that in these two countries the standard of atmospheric purity aimed at is considerably lower than with us under the Act as it stands.

In Dresden, however, a city which has long been noted as an example of amenity in civic management, we find that as far back as 1887 a by-law was enacted which goes beyond anything we have ventured even to propose in London, or elsewhere in the three kingdoms. It runs thus :—"In all manufacturing and industrial premises the construction of the furnaces must be of such a nature, and their stoking so regulated, that *no smoke containing visible particles of soot* is constantly emitted." "Where this happens only occasionally and exceptionally, the nuisance must not last longer than is absolutely unavoidable even with the most careful stoking, and the employment of coal of at least medium quality."

Two years were given as a period of grace to existing premises. But the Dresden authorities were not content even with this drastic dealing with industrial premises. They extended their

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hand against private premises as well; and the by-law further provided that "In private dwelling houses the heating arrangement must be so contrived as to produce as little smoke as possible."

To forbid black smoke absolutely, and coloured (visible) smoke almost entirely, appears to go very far, but the step was taken not unsympathetically. At the same time an official inspector was appointed, whose duties were not only to enforce the law, but to assist citizens in complying with it. Besides reporting offending premises, he was to hear all complaints against "the practicability and onerous nature of the by-laws." He was to inquire into and suggest improvements in means for combating smoke, and he had attached to him an expert foreman stoker, who assists him in his duties and "is frequently called on to give practical illustration of the effect of skilful stoking in reducing smoke."

In these admirable and highly practical provisions we seem to get a new note in legislation which is worthy of the fullest consideration. The serious opposition to any extension of the law comes from manufacturers, who plead in perfect good faith, and with convincing earnestness, that any further restrictions in smoke production are incompatible with London remaining a manufacturing city. On this point, however, there is no certainty. Many competent authorities share the belief of the German Government, that by well-constructed furnaces, reasonably good fuel, and, above all, by skilful stoking, the evil would practically disappear without crippling the industries concerned. The methods they recommend are in themselves methods of ensuring economy, and were State assistance provided to explain and bring home to manufacturers how such economies could be effected, there seems no doubt that the bulk of the opposition would be removed. The hint, therefore, that we get from Dresden is, that if we wish to get really efficient legislation carried through, it is highly desirable to accompany it with some provision for securing to manufacturers gratuitous instruction for stokers, and gratuitous advice on the general management of their fires. This at least appears to be the policy on which Dresden has been proceeding with so much success.

It remains to notice certain amendments suggested by American legislation. For though that country as a whole is far behind Dresden in the matter, some excellent provisions have been adopted by Philadelphia, Chicago, and Massachusetts.

In Philadelphia there is an ordinance to regulate smoke from chimneys, which incorporates a colour scale for the measurement of the density and darkness of smoke; and within the limits of the city it is forbidden to emit smoke of a degree of darkness in excess of scale No. 2 for a period of more than five consecutive minutes from any locomotive or steamboat; while

with regard to factories, &c., the scale of colour varies with the height of the chimney. The Chicago ordinance simply forbids the emission of "dense smoke" with a time-limit of three minutes.

Massachusetts appears to be the only State that has adopted a general Act. Section 1 of the Act of 1901 forbids as a nuisance the emission of "dark smoke or dense grey smoke for more than four minutes continuously, or for 12 per cent. of any continuous period of twelve hours."

It will be seen that the American legislature attaches importance to a time-period, that is, to having a minimum period during which the emission of objectionable smoke is permitted as unavoidable. No such period of grace has been enacted in this country, but in practice it is allowed. The length of such period differs in various places, and with various magistrates, just as does the interpretation of the word "black," and it would undoubtedly add certainty, and therefore efficient administration of the law, if we were to adopt, in amending our Act, some such time-limit as has commended itself to American experience.

Since 1905 very little progress seems to have been made to throw light on the comparative legislation of our subject. There are only two cases, so far as I have been able to ascertain, which call for notice. The first is an amendment of the Code of the State of Ohio, the history and effect of which is thus described in the Annual Report for last year of the Cincinnati Smoke Abatement League:—

"At the last session of our General Assembly, Mr. Krause of Cleveland, a former Chief Smoke Inspector of that city, and an earnest advocate of smoke abatement, introduced into the Senate a Bill to amend Section 3650 of the General Code of Ohio. The chief purpose of his Bill was to give municipal councils plenary power in the matter of providing for the regulation of steam boilers and steam boiler plants. As it is under this section of the Code that municipal smoke ordinances are enacted, we endeavoured to secure a modification of the Krause Bill with the especial view of strengthening our city ordinance and thereby meeting some of the objections urged against it. Our efforts were unsuccessful, largely because Mr. Krause and others working with him feared that if we pressed the amendments we proposed it would result in the defeat of the entire measure, the good features of which we cheerfully conceded.

"In the form in which Mr. Krause's Bill finally passed, it was an enabling act; it empowered municipal councils throughout the State 'to regulate and prevent the emission of dense smoke, to prevent the careless and negligent emission of dense smoke from locomotives, to declare each of the foregoing acts a nuisance, and to prescribe and enforce regulations for the prevention thereof.' The provision empowering Council to

declare the emission of dense smoke a nuisance was a distinct advance to the law as it previously existed; for the weight of legal authority was to the effect that Council could not declare anything a nuisance *per se* which had not been recognised as such at common law.

"This legislation at Columbus was closely followed by the introduction into our City Council of an ordinance designed to reorganise our local Smoke Inspector's office. It prescribed technical qualifications for the Chief Smoke Inspector; enlarged his staff and increased their pay; made the Chief's consent absolutely necessary for the erection and maintenance of any new plant or the reconstruction of an old one within the city limits; and provided for a scale of fees for issuance of permits to erect, and inspection of, plants. As originally drawn, this ordinance increased from six to ten minutes the time allowed in any one hour for smoking while the fire was being built or fire-box cleaned; it also provided that prosecutions under it should be instituted by the Chief Smoke Inspector in the name of the city. Both of these two features the League vigorously opposed as most injurious to the cause of smoke abatement. We were successful in having the latter stricken out, thereby allowing us to arrest and prosecute as provided by the ordinance under which we have been working for several years; but the ten-minute feature remained. After long delay, several hearings and much discussion, Council passed the ordinance, which was vetoed by the Mayor upon the ground of expense. The case stands, accordingly, as heretofore; we still are working under the ordinance passed December 30, 1907, and approved by the Mayor January 3, 1908."

From this it would appear that there still exist municipalities even in America not too anxious to avail themselves of the blessings which the legislature bestows. The other case is more encouraging—and I am happy to say it is from Canada—a by-law passed in May, 1907, by that highly progressive city Toronto. A copy of it has been kindly furnished by Mr. Commissioner Harris, of the City Department of Property and Street Cleaning. Here is the text:—

No. 4941. A BY-LAW.

To Compel the Prevention of Smoke.

(Passed May 13, 1907, as amended by By-law No. 5146.)

The Council of the Corporation of the City of Toronto enact as follows:—

I.

No owner, lessee, tenant, agent, manager or occupant of any premises or steam engine in which a fire is burned, and no person who operates, uses or causes or permits to be used any furnace or fire within the limits of the city of Toronto, shall permit the emission to the atmosphere from such fire, of opaque

or dense smoke for a period of more than six minutes in any one hour. The point at which such emission shall be determined shall be that point at which the smoke is discharged from the opening, flue, stack or chimney to the atmosphere. Nothing herein contained shall apply to any furnace or fire used in connection with the reduction, refining or smelting of ores or minerals or the manufacture of cement, or to private dwelling houses, except they be apartment houses of a greater height than three storeys and basement.

II.

No prosecution shall be commenced under this By-law until at least ninety days' notice in writing has been given by the City to the person to be proceeded against of the existence of the By-law.

III.

By-law No. 4266, entitled "A By-law to compel manufacturers and others creating smoke to use smoke consumers," is hereby repealed.

IV.

Any person convicted of a breach of any of the provisions of this By-law shall forfeit and pay, at the discretion of the convicting magistrate, a penalty not exceeding (exclusive of costs) the sum of fifty dollars for each offence, and in default of payment of the said penalty and costs forthwith, the said penalty and costs, or costs only, may be levied by distress and sale of the goods and chattels of the offender, and in case of there being no distress found out of which such penalty can be levied, the convicting magistrate may commit the offender to the common gaol of the City of Toronto with or without hard labour, for any period not exceeding six calendar months, unless the said penalty and costs (if any) including the costs of the said distress and of the committal and conveyance of the offender to the said gaol, are sooner paid.

W. A. Littlejohn, *City Clerk.*
(L.S.) E. Coatsworth, *Mayor.*

About the last section there is a thoroughness characteristic of a young and vigorous people, which I am sure will commend itself to all sympathisers with our cause. It has something of the ring of a trumpet call to further action, and with that I will conclude this somewhat barren record of neighbours' exertions.

A Plea for a Royal Commission.

By Dr. H. A. Des Vœux, M.D.
(Hon. Treasurer, Coal Smoke Abatement Society.)

It may be taken for granted that, in the abstract, few citizens of these Isles who have given thought to the subject, and, indeed, few informed inhabitants of the civilised world, would disagree with the propositions that coal smoke is a nuisance which ought to be abated; that it is dangerous, or at least injurious to health, destructive of works of art, fabrics, and even of stone, and many metals; that it is annoying and expensive by reason of the dirt it persistently deposits upon our persons, our clothes, and our houses; and, finally, that even if it were possible to regard it as one of the luxuries of life, it is certainly so costly that only a millionaire could do it.

There will probably be general agreement to this point; but beyond it mankind is divided into two camps. On the one side are ranged the vast majority who are responsible for making the smoke; on the other an infinitesimal minority who, making no smoke themselves, consider that its emission, owing to the negligence or indifference of others, should be prohibited.

For the purposes of this paper I can omit the greater number of the large army of smoke makers. They are the private householders, and the proposal which I am about to lay before you necessarily deals with the relatively small number of persons who only are amenable to the law—*i.e.*, those who in carrying on some trade or manufacture are responsible for the emission of smoke from the chimneys or shafts of their works.

The domestic smoke problem is tending towards a settlement by voluntary means, as is shown by the remarkable growth in recent years of the use for cooking and heating of gas, electricity, and various forms of solid smokeless fuels.

The manufacturer, however, has been subject to special legal restrictions for more than thirty-five years, and, unfortunately, all who have made the subject of smoke abatement a special study are bound to admit that such legal restrictions are necessary. In the past, manufacturers, as a body, have of themselves done little or nothing in the direction of smoke abatement and, with a few notable exceptions, as far as I know, are still doing little to scientifically study the problem. Their standpoint has always been, "We must carry on our trade, and for that purpose we must burn a cheap coal, and if we burn coal we must emit smoke."

The contention of the advocates of smoke abatement, however, is that while they have no wish to injure or harass trade, and

are willing to concede that *some* smoke must be emitted, the quantity emitted should not be sufficient to cause a nuisance. We further suggest that if the manufacturer treated his furnace as a scientific problem, and not by rule of thumb, he would create no nuisance, would not add one penny to his expenses, but in many cases would reduce them.

It may be asked what proofs exist of these assertions. During the thirteen years of the existence of the Coal Smoke Abatement Society it has made fortnightly reports to local sanitary authorities of smoke nuisances observed by an inspector. It has had the pleasure, during that time, of seeing the nuisance abated from almost 1,000 factories representing nearly every kind of industry. Each of those factories formed the subject of frequent complaint by the Society, and the original plea in defence was that it was impossible not to make smoke, and that even if the smoke were abated so as not to be a nuisance, the expense would be so great that the business concerned would be ruined. What has been the result? So far as we know, and it may be taken for granted that we should not be kept in ignorance, no works have ever been shut up or even injured by the means taken; on the other hand, we have evidence from many manufacturers that the abatement of smoke has led to the reduction in their coal bill or general working expenses.

It is thus apparent that smoke can be abated without inflicting any hardship upon industry.

If the results obtained during the short life of the Coal Smoke Abatement Society have been so striking, it may be asked why are we dissatisfied with the existing law? Our answer is that the results are uneven in distribution and have been principally confined to the inner ring of the Metropolis coming within the area of the London County Council's jurisdiction. Outside this area, with the notable exceptions furnished by the handful of cities having special powers, little or no progress is being made.

This is due to a variety of causes, amongst which may be mentioned :—

(1) Because the existing law is complicated.

(2) Because the local authorities, whose duty it is to put the law into force, sometimes refuse to do so, honestly believing that if the law were enforced the trade in their districts would be injured; and too often I fear they refrain from action because the representatives themselves either own, or are largely interested in, the premises involved.

(3) Because even when the law is enforced the magistrates before whom the case is tried often dismiss the case on some technical ground, or else inflict a paltry fine of a few shillings, which is no deterrent to a firm whose fuel bill is many thousands of pounds a year.

It is therefore not to be wondered at that local authorities have either become despondent or inert.

The reasons given by magistrates for refusing to convict in smoke abatement cases are varied. For instance, in the oft-quoted Lots Road Generating Station case, the summons was dismissed because the magistrate refused to accept the evidence that the smoke emitted was "black." A promise to instal new appliances is also sometimes accepted as an excuse. Amongst other typical recent reasons for the dismissal of summonses, the following may be quoted to show how difficult it is to secure convictions under the present law :—

(*a*) That reasonable care had been taken.
(*b*) That the emission of smoke was the fault of the stoker.
(*c*) That the Statutory Notice was out of date.
(*d*) That the Statutory Notice was wrongly served.
(*e*) That a mistake had been made in describing the chimney.
(*f*) That the case was trivial.
(*g*) That the quantity of smoke emitted was insufficient to justify conviction.

No doubt most of my audience are perfectly well aware of the law, but I must refer to it here. It is almost the same for London as for the country. The law for the country is contained in the Public Health Act, 1875 (Sec. 91). For London the Public Health Act of 1891 contains two sections which are intended to be operated against smoke. The first provides that any fireplace or furnace which does not, as far as practicable, consume the smoke arising from the combustible used therein shall be deemed to be a nuisance. The second provides for the imposition of fines upon the owner or occupier of the premises, or foreman, or employer, who uses a furnace employed in trade which is not constructed so as to consume or burn the smoke, or uses it negligently so that it emits smoke.

These words are a layman's epitome of the main smoke provisions of the Act, and to a non-legal mind like mine they seem to leave no loophole for escape for an unfortunate offender. But put a legal mind to pull it to pieces and the whole of the provision falls at once. So heavily has it fallen that not a sentence of it remains unbroken, and I believe that only in Glasgow has anyone been bold enough to put it together again. In England it remains simply as a memento of the good intentions of some Members of Parliament who were desirous of mitigating the smoke nuisance. As a means of bringing pressure upon offenders against the law it has been abandoned. We are therefore bound to fall back upon the alternative provision of the Act providing that "any chimney (not being the chimney of a private dwelling house) sending forth *black* smoke in such quantity as to be a nuisance" shall be a nuisance liable to be dealt with under the Act. Upon this, and this only, can we rely, and if it had not been for this Section there would have been in London no successful prosecution since the Act was passed.

I venture to assert that it was the obvious intention of Parliament that every furnace used in connection with trade should be constructed so as to emit the minimum amount of smoke, or, in other words, that it should emit no smoke that would cause a nuisance. If it did cause a nuisance it was, I submit, the intention of Parliament that the owner should be liable to punishment by fine, and that if he were so careless as to permit the emission of "black" smoke there was no possible excuse for him. No one who reads Mr. Hurst's excellent pamphlet on the law of smoke emission could have any doubt upon the matter; but when the intellects of the Inns of Court were set to work upon the Smoke Sections of the Public Health Acts they have broken them as effectually as a small pocket hammer can break a large plate glass window. One small hole, and the remainder becomes cracked and useless.

If, therefore, it is impossible to prove that the smoke is "black," and the Lots Road case showed how difficult a task that may be made, there is no redress under the existing Statute law, however seriously the smoke from a factory may defile a whole neighbourhood.

It is no wonder, then, that many local authorities find excuses for leaving the matter untouched, and that they cannot be induced to carry out the duties cast upon them.

That a great deal of dissatisfaction exists in consequence of the state of things I have described, is shown by the growing efforts of enlightened corporations to obtain from Parliament further special powers upon the subject. A number of local authorities, such as Glasgow, Bradford, Manchester, Liverpool, and Nottingham, have already secured such special powers, and, because they find the existing law inadequate and unsatisfactory, other bodies, such as the London County Council, are pressing Parliament to clothe them with the necessary power to effect the purification of the air. It is surely unwise that it should be left to individual municipalities to try to obtain by private bill legislation which, if desirable in one industrial community, is equally desirable in all. I venture to suggest, too, that in these days when co-ordination is aimed at in all things, it is not sound policy to set up a great number of special smoke provisions differing for each locality according to the whim of a Parliamentary Committee or the view of the promoter.

Under these circumstances, the Coal Smoke Abatement Society has come to the conclusion that the Government should be urged to appoint a Royal Commission to carefully inquire into the whole subject with a view to the passing into law of a General Act. No such inquiry has taken place in this country for 67 years, and there can be no doubt that its researches would prove invaluable from the point of view of the manufacturer as well as from the point of view of those who aim at the abolition of the smoke nuisance.

The Royal Commission might be directed to inquire :—

(1) What standard, if any, is desirable as to the colour or density of the smoke which should be deemed a nuisance ?

(2) How the colour or density of smoke can best be identified ; (at present a variety of methods are employed, none of which is altogether satisfactory, and some uniform rule is urgently required).

(3) Are the fines at present inflicted upon offenders sufficiently adequate to act as deterrents ?

(4) Who should be punished, the owner of the works, the engineer-in-charge, or the stoker, when smoke nuisances result from careless manipulation of well-equipped installations ?

(5) Should any industries receive special treatment ?

(6) Should Government Inspectors be appointed to act in regard to the emission of smoke as is done in the case of the Alkali Acts ?

(7) Should Government premises be placed under the obligation to prevent smoke nuisances ? (At present they are immune from prosecution.)

(8) Ought any hourly or other time limit to be fixed during which the emission of black or other smoke may fairly be permitted to issue from factory shafts ? (At present the time limits fixed by various municipalities vary between 3 minutes and 15 minutes in the hour.)

(9) Should all cases be heard by Stipendiaries ?

(10) Can the issue of an unreasonable quantity of smoke be prevented except in the case of breakdown or accident ?

(11) Can it be shown that the installation of proper appliances generally results in economy, as is contended by " Smoke Abaters."

(12) The incidence, intensity, and duration of fogs and their effect on health.

(13) The influence of smoke on health.

(14) The damage of smoke to buildings, works of art, and property generally.

(15) Foreign efforts to cope with the smoke nuisance.

(16) How far it is possible by Smoke Abatement to conserve our coal supplies.

(17) How far it is practicable to deal with smoke from private dwelling-houses.

Acting, therefore, on behalf of the Coal Smoke Abatement Society, I have to request you to join with us in asking His Majesty's Government to have the whole question of Smoke Abatement reconsidered by a Royal Commission, for the one great reason, that the Act which was passed in 1875, and which was intended as an effective instrument for the abatement of smoke, has been a failure, and that the time has come when the cause of that failure should be inquired into by an impartial tribune.

DISCUSSION.

FIRST DAY. MORNING SESSION.

"ECONOMICAL AND ARTISTIC EFFECTS."

(Papers 1—5.)

W. WHITAKER, Esq., B.A., F.R.S.

(*Vice-Chairman, Conference Committee*),

in the Chair.

At the opening of the Conference Mr. L. W. Chubb (Exhibition Secretary) explained that the Hon. Secretary of the Conference, Dr. Lessing, had asked him to apologise for his non-attendance owing to his marriage. All who knew Dr. Lessing's enthusiasm for smoke abatement would wish him every happiness.

On behalf of the Conference Committee and of the Coal Smoke Abatement Society, under whose control the Exhibition was taking place, Mr. Chubb extended a warm welcome to the delegates, and particularly to the delegates from nine foreign municipalities, and the official representatives of the Swedish Government, and of the Minister of Commerce for Holland.

Mr. Walter Reid, F.I.C., referring to the effect on building materials of the air in towns, expressed the opinion that architects were to blame for choosing unsatisfactory materials, while artists who designed statues and monuments were even worse at fault for adopting such materials as bronze and marble which should be avoided in a city like London. Our climate was unsuitable for them. As an instance, Mr. Reid cited the Tivoli in the Strand, where there was some fine marble work and castings of bronze; but in a year the whole of the marble went green and then black as the result of the sulphur compounds in the air.

In the case of the Strand statue to Mr. Gladstone, the limestone upon which the bronze rested was already stained a very bright green, which showed that the influence of the atmosphere on the bronze was great and corrosive.

As a result of a number of experiments in Berlin, Dipple's oil, an animal oil, was found to give the best preservative effects. Paraffin wax would not last long on metal, but on stone was very useful, and Mr. Reid preferred it to baryta water, because when the stone was saturated with that carbonate of baryta was formed, and probably the crust would afterwards peel off. In Berlin there were some beautiful frescoes by Karl Bach which were treated with baryta water, but although the surfaces were protected at the beginning, they began to peel off and were now quite a wreck. If the material only penetrated the stone a very short distance it would probably scale off.

Mr. Caröe, the architect in charge of the restoration of Canterbury Cathedral, had been making some interesting experiments lately with another method of protecting stone by using arsenic acid, and had got some encouraging results.

There was no doubt at all that the use of a lime wash was a very good thing indeed; it gave something that would allow the acid to be neutralised, and yet did not interfere with the appearance of the building itself.

The action of vegetation on stone should also be remembered. Roots would dissolve a piece of polished marble and corrode it. There was a great deal of vegetation in incrustations, and on account of there being so much ammonia in our atmosphere, mosses and suchlike organisms grew very rapidly indeed.

With regard to materials to be used, no doubt the best were vitrified materials of a ceramic nature. The material of which the Natural History Museum was built had hardly been acted upon at all—it was a kind of fire-clay—but the Portland stone forming the supports of the gates outside had been corroded in many places to a depth of ¼in. That was a good comparison between a limestone and a vitrified material.

Bailie W. Smith said that if the title of the Coal Smoke Abatement Society limited it to consider the effect of smoke alone on air it should change its name and get an extended jurisdiction. When he began the work in the Glasgow Corporation six years ago, they had a Sub-Committee for the prevention of black smoke, and he induced the Council to change it to the Sub-Committee of Air Purification. That included everything that got into the air from coal or anything else.

Councillor Kinnaird (Lambeth) said that, as a practical builder, he used something like 18 to 20 tons of white lead a year, and the question of damage owing to the sulphur had been a serious question to the decorating portion of the trade. That morning his attention had been called to a case where the whole side of a house had turned completely black owing to the action of the sulphur in the air. The only thing to remove it would be oxalic acid diluted with water.

Mr. Watling (Bradford) said that in the West Riding of Yorkshire most of the public buildings were built of sandstone, and the action of the air upon it caused a considerable amount of blackening. Could Sir Arthur Church suggest any particular method to apply to public buildings in order to restore them to their original colour and condition without damaging the surface of the stone ?

Sir Arthur Church : The porous sandstone to which reference is made has a binding material of carbonate of lime ; and when that is acted upon the surface becomes rough in the course of a few months, or years, and the soot lodges upon it ; and I do not see that any process of saturation other than one of the two materials I recommend would be of any use. Those substances are baryta water, properly applied, and hard paraffin wax prepared in the form of an ointment. I call it an ointment because you may spread it on the plaster, or painting, in the form of a semi-transparent paste, and this is spread with a fillet knife, or rubbed in with a hog bristle brush, and after two or three days, when the toluol has evaporated, you drive the paraffin wax on the surface into the stone by means of a chafing dish, or a Bunsen burner, or spirits of wine, and in that way you render the surface non-absorbent, and no longer a suitable place for the lodgment of soot. But at the same time I am bound to allow that paraffin wax, except in very rare instances, has a tendency to gather tarry matter and soot from the air, and although these can no longer penetrate and further affect the stone, they do produce a somewhat dirty and grubby effect upon the surface. Paraffin wax is best made with about 20 per cent. of hard paraffin wax with a melting point of about 150° or 160° Fahr., and the rest a solvent which is used as a medium, rather than a material, which forms the solution. Although they are not always successful, they are, at least, ameliorative.

I have, of course, never recommended baryta water to be applied to bronze statues. What I have recommended is a linseed oil which is occasionally used for bronze. I am not prepared to go further than that, and give a general recommendation for the preservation of works of art. Put them under glass wherever you can ; put them under hard paraffin wax wherever possible, but only in minute quantities. Paintings, or stereochromes, or frescoes may be preserved with paraffin wax (not beeswax, which has a tendency to perish) properly prepared, with a high

melting point, and not sticky like earth wax. You can paint on a wall with water colours, using honey of glycerine ; let it dry, and then coat it with paraffin wax, and then you will find, although a little change of tone, very little deterioration of the scheme of colouring of your picture.

The CHAIRMAN, in proposing a hearty vote of thanks to the authors of the papers, referred to Mr. Reid's remarks about the effect of bad air on stones, and the withering away of Portland stone, leaving the fossils standing out. That took place in the open country as well as in towns, the reason being that the fossils were of crystalline calcide, which was less soluble than the ordinary lime which made up the body of stone. He had no doubt that the action would be quicker in foul air, however. In fact, a friend of his who lived in Bristol used the smoky air of that town to develop his fossils. The same result could be obtained by using dilute acid, but Nature did it rather better.

FIRST DAY. AFTERNOON SESSION.

"EFFECTS ON ANIMAL AND PLANT LIFE."

(Papers 6—9.)

SIR WILLIAM RAMSAY, K.C.B., F.R.S.,

in the Chair.

Councillor MUIRHEAD (Liverpool) observed that Miss Agar had said the plane tree had every qualification for town life excepting its size, but in Liverpool, where they were not troubled with an enormous quantity of smoke, the plane would not thrive. He advised anyone who thought of planting the plane to test it in small quantities at first, and not start with wholesale quantities.

Miss AGAR said that the plane was not very hardy, it would grow scarcely anywhere in Scotland. Perhaps the prevailing north winds at Liverpool might account for its failure to grow.

Alderman CLARK (Leeds) remarked that Mr. Ruston had implied that the manufacturers of Leeds were the greatest offenders in turning out smoke or soot, but Professor Cohen had said that the domestic soot or smoke turned out was something like five times more than the soot or smoke turned out by the manufacturers of Leeds. However, he had to admit that they had much soot in Leeds, and a lot of stunted trees and vegetation, but the conditions were improving.

Dr. OWENS, referring to a recent statement by Dr. W. N. Shaw, that there was a possibility of fog being produced by the sulphurous acid gases in the air without any soot, suggested that a comparative table of sunshine should be prepared for some city which was smokeless, showing the sunshine there, and in a city in the adjoining country where the smoke nuisance still existed, with the object of bringing out what was the maximum effect that could be expected by removing the smoke.

Councillor GILLHAM (Hammersmith) asked what effect smoke pollution would have on milk.

Alderman CLEMENT (Wimbledon) thought it would be of some help, on the question of the growth of trees in certain cities, if they knew the condition of the soil in which the trees were planted, and also the treatment they had received.

Mr. MUIRHEAD said his point was that it should not be laid down as a general principle that the plane tree was good for all towns. The Liverpool soil was principally red sandstone with a certain amount of clay. Where the plane trees had been planted there was plenty of good deep soil—he should say, black soil.

Miss AGAR said several local authorities even in the South of England

had complained that the plane would not grow properly, but on investigation it transpired that the soil was, as Mr. Muirhead had said, black, and had lost all fertility. The plane did not thrive in the northern part of England.

Mr. Lempfert, in reply to the question raised by Dr. Owens, said that a smokeless city would be hard to find. For the purposes of comparison it would be necessary to have a country place near the city which had had sunshine records taken over a long period. He thought the observations of Dr. Shaw were meant to show the effect on sunshine of sulphur fumes in the atmosphere when sunshine seemed to have the effect of producing condensation and so causing a fog, so that it was not purely the carbon, but also the sulphur fumes that were responsible for the actual cutting off of the sunlight.

Mr. Ruston, in reply to Alderman Clark's criticism, said that in the case of a factory chimney the smoke was all being belched out in a concentrated mass. If the sulphur fumes were present to a small extent there would be little effect, but if the emission was concentrated the amount of sulphur in the air was enormously raised, and the trees almost entirely destroyed. In Ardsley, every one of some forty trees that had been planted there had been killed off by factory chimney smoke.

With reference to the milk supply, undoubtedly the milk of Leeds and of Garforth (which was seven miles from Leeds) was affected indirectly by the prevailing atmospheric conditions. Among the main constituents of milk were lime and phosphoric acid, both of which were exceedingly important for the building up of a bone formation. In ordinary milk the ratio of lime to phosphoric acid was one to one ; in the Garforth milk—and he had analysed the ashes of over one thousand samples—he had found the ratio of lime to phosphoric acid, instead of being one to one, was one of lime to one and a-half of phosphoric acid ; that was to say, there was not enough lime in the milk to satisfy the ordinary conditions. This was due in a large extent to the sulphuric acid falling on the soil and washing out a great deal of the lime, and so affecting the grass.

With reference to the question, if smoke were done away with would they also do away with the acid in the atmosphere, his answer was undoubtedly no. But there was this fact which also had to be contended with, that when the soot was turned out it would contain a large amount of tar, in varying amounts, and that tar when it settled on the leaves of trees would not be washed off. Practically all soots were acid, and the acid deposited on the leaves by the tar was retained and not easily washed off.

The Chairman (Sir William Ramsay, K.C.B., F.R.S.) said he had been brought face to face with the presence of things in the atmosphere by having to weigh them. Some years ago it had become necessary to get pure water, but it was found to be absolutely impossible to get water that did not leave an easily perceptible residue under the microscope. Take even a drop of distilled water, and under the microscope it had what looked like a shore of crystallising matter, and the crystals appeared to consist of common salt, sodium nitrate, and other constituents, and the only way to get rid of those was by filtering through cotton wool, in which case if the liquid was evaporated in liquid air they got no residue. They all knew in water there were little particles of air which were in rapid motion. In order to stop this the water had to be made a conductor, and that could easily be done by putting in any common salt, or acid, and then the particles collected together and settled. It was only possible to make the water a conductor, and the particles to settle, in one or two particular ways. One way was by the use of ultra-violet light, which, by heating the particles, made the air in the neighbourhood conduct, and then the particles would touch and fall. Another was that there was always a certain amount of residuum in the air which caused the particles to touch and coalesce, and so fall.

Smoke prevented the ultra-violet light coming into the air, because a very little yellowness in the air would stop the ultra-violet light. When the particles began to grow, water collected and formed particles which were the basis of a fog. If the number of particles were reduced, the drops were larger, and the fog would clear sooner by mist or rain falling. Those were a few of the scientific considerations that had occurred to him after hearing the papers. One thing they were perfectly agreed upon, that there was no doubt that the chief sinners in the way of producing an absence of ultra-violet light were the producers of smoke, and they had met together to do all they could to help each other, and to help the legislative and other bodies generally to do away with air pollution. He thought everyone would agree with him that the papers they had listened to were conducive to that purpose, and increased the argument for doing away with the nuisance.

SECOND DAY. MORNING SESSION.

"WORK DONE AND TO BE DONE IN ORGANISING PREVENTIVE ACTION."

(Papers 10—17.)

SIR WILLIAM RICHMOND, K.C.B., R.A.

(*President Coal Smoke Abatement Society*),

in the Chair.

Sir WILLIAM RICHMOND, K.C.B., R.A., in opening the proceedings, specially welcomed those gentlemen who were foreign to this country, foreign only in fact of birth, but in sympathy in this undertaking. He also welcomed all the delegates from the municipalities of England and Scotland who had come and were serving in this important crusade under the same flag, that a healthier and freer atmosphere in our great cities might be attained.

Mr. L.W. CHUBB, Secretary, said that to bring up to date the figures given by Mr. Kershaw, and the information furnished by Bailie Smith, the Gas and Electricity Companies of London had supplied him with particulars of the appliances which they served. The Metropolitan Gas Companies at the end of 1911 were supplying gas-heating, cooking, and hot water appliances to the number of 1,494,000. That total had grown from 46,000, at which it stood only twenty years ago. The total five years ago was 989,000. The Electricity Supply Companies said that five years ago their output of power was 73,890 h.p.; it had grown to 207,000,000 units by 1909, and to 242,000,000 units in 1911 for power and heating purposes. They also stated that about 560,000 tons of coal were used in 1911 in the 14 municipal and 13 privately owned electricity supply undertakings of London furnishing returns. In each case the returns showed a remarkable expansion in the use of methods of smokeless heating and power production.

Dr. HAWKSLEY (Asst. M.O.H., Liverpool) did not agree with Inspector Nicholson's remark respecting the colour of lungs. No doubt the lungs did change from pink to black in some cases, but it had been his experience that in many post-mortems he had found the lungs quite normal. He admitted, however, that the deposit was injurious to health.

In regard to the domestic chimney, their chief difficulty was to overcome the prejudice of the British public for a brightly burning coal fire. However, he thought the Coal Smoke Abatement Society would be well employed if they did their best to get gas and electrical heating

appliances installed in huge blocks of offices, large shops and kitchens, and so on, where matters of sentiment did not prevail.

Mr. E. D. Simon (Hon. Secretary, Smoke Abatement League, Manchester) said that they had decided to start a branch at Manchester, and to appoint an inspector of their own. They had raised enough funds for their work for three years, and hoped that by the end of that time they would be able to demonstrate they had achieved something. In order to do that he felt it was necessary to have some method of recording the amount of smoke, fog, and sunshine ; and he would like to urge that Mr. Kershaw's suggestion for some standard method should be adopted.

Alderman Crole-Rees (Islington) said that in Islington they had laid down over half a million of money on their electricity undertaking, and were charging 1d. a unit for motive power, and their consumption in that direction had increased a hundredfold in the last six months. They were charging 3d. per unit for general lighting purposes.

Councillor Irving (Burnley) said that Mr. Donnelley's paper instituted an entirely new idea, for which the municipalities of this country had hitherto refused to take any responsibility, but he approved the proposal that something should be done in the direction of the corporations taking the responsibility upon themselves of giving advice. Up to the present they had practically relied on punitive measures.

Alderman Hey (Halifax) imagined one of their chief difficulties was to get the price of gas and electricity reduced to such an extent that they would become more universally used. One difficulty was the practice of allocating so much of the profits of the gas works to the relief of the rates. Halifax was a comparatively small town, having about 100,000 inhabitants, yet in the last year, out of their gas works revenue, they were contributing no less a sum than £19,000 to the relief of the rates, which, even with that relief, amounted to 9s. 8d. in the £. They were selling gas at 2s. per cubic foot and were proposing to loan out and fix gas cookers without any cost. In the electricity department, in order to encourage power users to adopt electricity, they had fixed a scale which would bring the cost of current down as low as $\frac{5}{8}$d. a unit.

Mr. Clayton (Manchester) said he thought that a point which had not been sufficiently dwelt upon was the coke produced in the manufacture of gas. In the manufacture of gas an enormous amount of coke was produced, and if it were raised in price to that of coal, the price of gas would be so much reduced as would make it possible to use it even for burning the whole day long. Anyone who had been to New York and seen the conditions there could appreciate the ease with which big buildings were heated, and what enormous scope there would be in London and other big cities in this country to heat their warehouses with coke.

With regard to domestic smoke, and the difference between that and factory smoke, an analysis made by himself some eight years ago showed that domestic smoke contained about 29 per cent. of tarry oils per 100 parts of carbon present, and 34 per cent. soluble in caustic soda. He then collected the blackest boiler soot he could get and found that that contained less than 2 per cent. of tarry oil per 100 parts of carbon. That showed conclusively that most of the discoloration of town buildings was due to domestic smoke on account of the tarry matter which it contained making it adhere to the surface.

Councillor Bashforth (Sheffield) remarked that in Sheffield, as the result of an exhibition held there three years ago, a very great advance had been made in the supply of gas stoves and gas furnaces. For several months after the close of the exhibition the different gas stove companies who had exhibited had to employ special representatives in the city for selling stoves ; whilst, in its report for 1910, the gas company reported that it had fixed 98 gas furnaces in steel works, and last year 78.

Mr. Macaulay (Liverpool) agreed with Herr Nies that the air supply to furnaces was the whole crux of the question. If the air was allowed to be mixed with the gases coming from the burning coal at a sufficiently

high temperature, instead of causing a cooling effect it increased the temperature ; and the method of admitting air over the top of the furnace amply paid the person who adopted it.

With regard to domestic furnaces, he thought a considerable amount of benefit might be obtained from central heating. In America the central heating of buildings in a block was very economical and advantageous, and the heat was sold out by meter.

In Liverpool they had found that the best results were obtained from chimneys which were not too high but high enough to carry the products of combustion over the surrounding buildings. Where induced draught was installed the air supplied to the furnace was better controlled.

Provost Muir MacKean (Paisley) said his town was the first in Scotland to supply free cookers. That had been going on now for some years and had been of immense advantage, and had manifestly decreased the amount of smoke. Further, they had had classes for firemen which had been by far the most successful of any classes in any part of Great Britain. The reason for this success was not only the enthusiasm of the men, but the kindness of the employers in paying the fees and encouraging the men in every possible way to attend the classes.

In order to set a good example to the manufacturers in the district, when he became Provost of Paisley, he induced his partners to make a clean sweep of their defective engine and boilers, and they expended some £7,000 in modern apparatus. As the result of taking special pains in the construction of the new boilers and chimney a saving of 16 per cent. of fuel had been effected, and in these times that saving of 16 per cent. meant a good deal. They did not regret having spent the money, for not only was it giving a fair return, but they were able to say they had done something to set a good example to their neighbours.

Mr. L. W. Chubb, in reply to a suggestion that an effort should be made to start in London, or elsewhere in England, a Society on the lines of the Hamburg Society, said that three or four years ago the Coal Smoke Abatement Society, realising what splendid work was being done in Hamburg, did its best to start such a Society here. He was directed to communicate with something like 400 manufacturers in London to give them full information of the Hamburg Society, and suggest they should help to form a similar organisation here. The Society intimated that it wanted nothing to do with the management, but would give every assistance in the formation of the proposed body. He was sorry to say that as only two manufacturers out of the 400 agreed to participate, the proposal had to be dropped.

SECOND DAY. AFTERNOON SESSION.

"THE PHYSICS OF SMOKE ABATEMENT APPARATUS AND PRACTICAL EXPEDIENTS FOR THE ABOLITION OF SMOKE, BOTH INDUSTRIAL AND DOMESTIC."

(Papers 18–24.)

CAPTAIN H. RIALL SANKEY, R.E. (ret.), M.I.C.E., M.I.M.E., in the Chair.

The Chairman, in opening the discussion upon the papers read that afternoon, said that Mr. Pearson's paper gave them food for thought. He had made out his case for the appointment of inspectors, and pressed that efforts should be made to secure the support of factory proprietors. He (the Chairman) thought those were most valuable suggestions. It interested him to learn a few days ago that on the other side of the " herring pond " they could do without smoke to a large extent, and that the manufacturers found it cheaper to have mechanical stokers, or put in smoke-preventing

apparatus, than to emit smoke. Recently he had been given a guarantee of mechanical stoking as regarded the prevention of smoke. Three boilers had been fitted with mechanical stokers, and one with a grate for hand-firing. The guarantee was that the mechanical stokers would give the same steam evaporation when smudge coal, costing about 10s. 6d. per ton, with a calorific value of about 11,500 b.t.-h.u. per lb., was used, as the hand-fired boiler would give when using coal at about 18s. per ton and of a calorific value of about 13,500 b.t.-h.u. per lb. The mechanical stokers were to do that work without producing any smoke or grit. Under those circumstances the hand-fired grate would certainly produce smoke.

Bailie Smith (Glasgow), in connection with stoking furnaces on steamers, said that the chief engineer, and not the firemen, should be certificated, and, if the chief engineer could not control his firemen, he ought not to be there. He did not know why, when the pleasure steamers of our British waters spent thousands of pounds in trying to get tourists, the tourists who travelled by steamer should be overcome by smoke. If they went on the steamers of Paris or Lake of Geneva they would not see any trace of smoke. In regard to stoking, the only thing for the companies was to get good men. If they paid good wages they would get good stokers.

Mr. J. B. C. Kershaw hoped that one result of the Conference would be that they would introduce some method of granting certificates to stokers. If where lectures for stokers were held, in Liverpool, Manchester, Glasgow, and other places, they would grant certificates, employers of labour and of stokers would recognise those certificates, and would pay higher wages to those men who had them. Something, too, should be done to standardise that work.

Mr. O. J. Parker said that he could assure Mr. Scott-Moncrieff that in regard to smokeless fuel there was no trouble whatever now as to the regularity of the product, neither was there any trouble whatever with the gas in the retorts during manufacture. By the method of a low temperature and a high vacuum the whole of the smoke element could be eliminated—high vacuum of about 25 inches. The retorts used did not wear out in the same manner as ordinary high temperature retorts. The operation took about a third of the time of the ordinary distillation of gas, and the result was that the products were all collected, and there was nothing lost whatever.

Mr. Turle said that he had some experience in retorts and high vacuum, and there was no difficulty in maintaining in retorts the degree of mercury referred to by Mr. Parker.

Mr. Tilden Scott stated that in 1903 an engineer came to him with a proposal to carry out a scheme similar to that which Sir William Ramsay advocated the other day. The suggestion was made to work some deposit 40 miles out of Melbourne, which could be harnessed for the electrification of the Melbourne Tramways. But afterwards the engineer told him that the deposits of coal were gradually changing into coke, and gas was coming out in various places. The scheme seemed possible. The gas, in the case he referred to, was made by some fire started ages ago. The thing had interested him very much as an electrical engineer, because, of course, the whole problem of our maintaining our position in the world would depend on cheap power. With our present methods of burning coal or gas producing we could not possibly compete with water power. With that power current could be made at very small cost.

Dr. Owens said that one thing had struck him, and that was the lack of co-ordination in all the efforts which were made on smoke abatement matters. They had there delegates from all parts of the country, and all the various societies interested in smoke abatement, but a lack of co-ordination existed. The various bodies interested in the prevention of smoke should bring into being some magazine for co-operation. If, too, they had some way of measuring in weight and atmosphere it would be helpful. Professor Cohen and others had suggested different ways

of arriving at the solids of the atmosphere. The main point for the moment was not the detail of how it was to be done, but how some standard method of doing it should be arrived at.

Principal J. W. GRAHAM said he should like to say that with regard to the suggestion of co-ordination at the present time, so far as he knew, there were only two smoke abatement organisations in the country. One was the Coal Smoke Abatement Society in London, and the other the Smoke Abatement League of Great Britain, which had its centre at Manchester, and was endeavouring to draw in supporters from the provinces. The object Dr. Owens had aimed at, namely, the classification of one another's work, could only be achieved by the aid of a magazine or periodical, and if either organisation felt financially strong enough to publish a smoke journal it would be a great advantage.

THIRD DAY. MORNING SESSION.

"PROPOSED NEW LEGISLATION."

Papers 25–26.

W. WHITAKER, ESQ., B.A., F.R.S.

(*Vice-Chairman, Conference Committee*),

in the Chair.

The CHAIRMAN (Mr. W. Whitaker, B.A., F.R.S.) said they knew what was meant by "black," but if a poll were taken of all those present he felt sure as many opinions would be given on that word as there were people in the room. Technically, black meant absence of all colour. You could only get that where there was a total absence of all light. The expression was used roughly, just as red wine and white wine. Red wine was sometimes red, but white wine was never white. Black did not mean techically black, it meant something that was dark. In the region of the cement works on the Thames they would find a very irritating kind of smoke which certainly was not black, and that sort of smoke should be amenable to the law just as much as other smoke that was more highly coloured.

Bailie SMITH said that Glasgow would strongly oppose any such word as black, because in their Special Act no such word occurred; it simply said "smoke." They would also oppose anything like limiting, or exempting any furnaces whatever. The Glasgow Act gave no exemption. It said, "Smoke from any fireplace or fires, other than a domestic fireplace"; and he thought those were the lines to go upon. They, however, felt strongly the necessity for the creation of a general authority that could be appealed to (not to take the place of the local authorities) to enforce the law.

Councillor MUIRHEAD (Liverpool) suggested that what was required was the wording of the Liverpool Act: "Any unnecessary or excessive quantity of smoke, or causing any annoyance to the inhabitants of the city, without using the best practical means to prevent such annoyance."

Councillor JOHNSTON (Manchester) said he was sorry for the compromise, because black was the great difficulty they had in Manchester at the present time. There they never brought a case before the Sanitary Committee unless black smoke was emitted for two minutes in half an hour. That was one of their greatest difficulties in abating the nuisance, and it would be removed by abolishing the word "black." Unfortunately, magistrates too often were ready to take any excuse the manufacturers offered; they were afraid of manufacturers being driven away, but he, for one, said to them, "Move your works as soon as you like, if you have no consideration for the public interests."

Councillor Hanney (Glasgow) emphasised Bailie Smith's views that the Glasgow Council, and their Smoke Department, were very much against the word "black."

Mr. Jackson (Manchester) said there were points in the Bill upon which he had grave doubts. It exempted premises used principally for domestic purposes, and that opened the way for exemption for institutions which were very objectionable and grave offenders at the present time—hotels, clubs, hospitals, and even laundries might claim exemption under that clause. He preferred the original Act because it simply exempted residences. The existing Act, too, only exempted certain processes, whereas the proposed exemptions for metallurgical, or pottery furnaces, would bring in nearly all processes of iron manufacture. He also objected to section 2 (3) which provided that no person should be prosecuted or otherwise proceeded against under the Act unless notice of intention to proceed was given within 24 hours. In all cases it was the local authority who must determine whether proceedings were to be taken or not, and they only met weekly or fortnightly. If they were to insist upon notice of a committal of an offence being given that would be better than notice of intention to proceed; but in any case, 24 hours was too short. It was true the clause excluded Sundays, but there were also Bank Holidays, Good Fridays, and so on, at which times it would be impossible to give notice within the stipulated 24 hours, he thought 48 hours was quite little enough.

Inspector Macaulay (Liverpool) said that in the Liverpool Act the words inserted were "unnecessary or excessive smoke"; no reference being made to any colour whatever. In Liverpool they had never lost a case on the colour of the smoke. There had been one decision against them in the High Court, but that was on a technical expression with regard to a steamer which was shown to be a foreign-going steamer, and consequently exempt. He was of opinion that to introduce the word "black" would be a retrogressive step.

Mr. Kershaw asked whether there was any chance at all of the proposed Act going through within the next five years; if not, it seemed to him they were wasting a great deal of time and energy on the Bill.

Mr. Watling (Bradford) said that along with Glasgow and Liverpool, Bradford believed it would be destructive in administration to let the word "black" creep back. He drew attention to the Lots-road Generating Station case. Experts for the Chelsea Borough Council swore that the smoke was in fact black; but experts on the other side said it was not black, but a dark grey; and the magistrate came to the conclusion that although the smoke was apparently black it was not really black. That was the sort of difficulty they had to fight against.

It had been stated that black smoke of itself could be dealt with under Section 91 of the Public Health Act, without it being a nuisance, but as he understood the wording of that Section, it meant the black smoke had to be in such quantities as to be a nuisance before it could be dealt with under the Act of 1875. "Any smoke emitted in such a quantity as to cause a nuisance, inconvenience, or annoyance" would cover any conceivable form or kind of smoke, and, therefore, apart from the apparent objectionableness of the word black, there was no legal reason why it should be inserted.

The particular wording of the smoke clause was considerably debated when the Bradford Bill was before Parliament in 1910, and the clause settled on then would prove a precedent for future legislation. In Bradford they had special forms of intention to prosecute printed, and when the inspector, who carried the forms with him, saw an offence committed, he went to the works, or registered office, and left a form immediately. The notice was a purely technical form, and would give rise to no difficulty.

Inspector Nicholson (Sheffield) said he was not in favour of the Bill, and preferred the existing Public Health Act. In Sheffield their method

was to show that the smoke complained of was unnecessary for the carrying on of the particular trade. They had had scores of cases which they had won in Sheffield because they had proved, even in the case of metallurgical furnaces, that more smoke had been emitted than was necessary for the generation of steam to carry on the manufacture. He thought the retention of the word black desirable.

Mr. Hurst, in reply, said that they owed thanks to the promoters of the Bill for having given them a backbone to talk about. He did not suggest that black smoke could, by itself, be a nuisance, but that they must prove the issue of black smoke "in such quantities." As soon as they did that, they had not to go on to prove that any person or property had been injuriously affected. In this connection there were the cases of Weeks *v.* King, *Ex-parte* Schofield and the South London Electric Supply Corporation *v.* Perrin. As soon as the Court was satisfied that black smoke had issued in sufficient quantity, they had not got to say that any particular person or property had been affected.

In the Lots-road case, the magistrate, in giving judgment, went off from the question of whether the smoke was black or not, and whether it was issued in such quantities or not, to discuss what a magnificent thing it was that they had tube railways in London, and what a shame it was they should try to suppress the smoke (which no doubt was of a suspicious colour) when they could ride in those beautiful carriages and get to various places so much easier than was the case before their advent.

It had been suggested in some quarters that if you had the language "black or other smoke," the Courts would be liable to follow the principle very generally adopted, and treat it as being governed by the *ejusdem generis* doctrine, and, therefore, it carried it back to the word black. That was a suggestion that had been made, but he did not agree with it.

It had been said uniformity would be secured by the proposed Bill. Well, had they not got the possibilities of uniformity where they had the presiding power of the Local Government Board on the one hand, and the powers of the London County Council in the case of London? He submitted that it was unnecessary to set up more authority to do practically the same thing over again, for the proposal to have a central authority was really to take the place of, or to run at the side with, the Local Government Board. In the interests of smoke abatement, it was very undesirable that at the present time they should appear to increase the cost of administration. He thought if they could stir up the Local Government Board, then the authority proposed to be set up, at great cost and with uncertain results, would be unnecessary. In the London County Council they had a sufficient superintending body keeping a watch on the operations of the various metropolitan bodies.

Principal Graham said the Bill was the result of the combined opinions of the most expert authorities, and the most conflicting interests, that they had been able to gather during the last three years; and that policy of endeavouring to comprehend within the scope and purpose of the Bill all reasonable thought, he had followed again that morning by suggesting that they were willing to take in a double phrasing and say, "black smoke, or smoke in such quantities as to be a nuisance or inconvenience, &c." It was not a compromise; nor had he at all changed his views upon the views he held the previous evening, or at any other period; it was an extension of the regulations and of the forces for prosecution.

Mr. Kershaw had asked whether they anticipated the Bill would pass within five years. If it did pass within five years, he would feel that a great part of their work had been successful. The immediate use of the Bill was that it was a kind of backbone or foundation round which discussion would centre, and should there be a Royal Commission, it would form the subject matter of that Commission's discussion. The reason why they had adopted the phraseology they had in the proposed Act,

rather than that of the Glasgow, Liverpool and Sheffield Acts, was because the word "practicable" occurred in those local Acts, and they felt it rendered one helpless before certain trades, or, at any rate, rendered it a long and difficult legal process to prove "practicable" or "impracticable."

He thought the criticism about the cost of exemption was rather unfortunate. That was not a legal matter, and it was intended to avoid litigation and to have something which cost hardly anything. As a matter of fact, all it amounted to was that in getting a certificate of exemption they paid half-a-crown. It was of no importance, but had to be put in the Bill.

The London County Council was simply put down as one of the district authorities. London was not exempt from the Act in any way, but it was thought best to ensure that there would be no interference with the local work of the London County Council. The Local Government Board had an authority under which, by a mandamus, they could compel local authorities to act.

Mr. Hurst said that under the 1875 Act they had power to act in default of the local authority, and charge the local authority with the expense.

Mr. Graham replied that there were such difficulties in the way of that Act that it had never been carried out, and it was quite useless for anyone to appeal to the Local Government Board for help. What they proposed was that the Local Government Board's help should be properly organised, and it was not a case of another authority being set up, but the same authority transferred from uselessness to serviceableness.

In Section 1 (4) the words "metallurgical furnace" would not be extended to all metallurgical furnaces; and if they would look upon it as a limiting, and not an extending, expression, he thought it would be understood.

He thought he might plead that the usefulness of the Bill was that it was constructive and administrative as well as punitive, and he hoped to furnish the public with a well-qualified administrative machinery which would work smoothly and be valued by manufacturers.

THIRD DAY. AFTERNOON SESSION.

"THE EXISTING LAW AND ITS ADMINISTRATION ABROAD. PROPOSED ROYAL COMMISSION."

(Papers 27–28.)

W. WHITAKER, Esq., B.A., F.R.S.,

was elected to the Chair in the absence, through indisposition, of

Lord Justice Fletcher Moulton.

Dr. Des Voeux (Hon. Treasurer, Coal Smoke Abatement Society) moved the following resolution:

> "THAT this Meeting of delegates of the International Smoke Abatement Conference recommends that the offer of Mr. A. Gordon Harvey, M.P., to introduce into Parliament the Smoke Abatement Bill prepared by the Smoke Abatement League, be accepted, and that should such Bill not be passed into law, during the current session, or should there be no prospect of the Bill passing in 1913, steps should be taken to organise a deputation to the Government to urge the appointment of a Royal Commission to report upon the whole subject of Smoke Abatement."

Principal Graham (President, Smoke Abatement League), in seconding the Resolution, remarked that there was some doubt on the question

as to whether the Royal Commission proposal would help or hinder the Bill, but it had been agreed that action with regard to it should be postponed until a chance had been given to the Bill.

Mr. NICHOLSON (Sheffield) thought that it would expedite matters if they were to suggest a Royal Commission first.

Mr. E. D. SIMON urged the delegates to pass the resolution unanimously, and Dr. DAY supported the resolution as a compromise, though he thought that there was no necessity for a Royal Commission.

Dr. DES VOEUX said that Lord Justice Fletcher Moulton told him as an old Parliamentary hand, that even if the Bill were introduced in Parliament, he thought there would be no chance of getting it through for many years. He was, however, personally quite agreeable to the compromise, while believing that until they had a Royal Commission they would never get a Bill through unopposed.

The resolution was carried unanimously with applause.

Dr. JOHN S. OWENS moved, and Mr. KERSHAW seconded, the following resolution, which was carried unanimously :

> "THAT in the view of this Conference it is desirable that immediate steps should be taken to decide upon and secure the general adoption of a standard method for the measurement of atmospheric pollution by smoke and other products of combustion and heat, in order that the data now being collected may possess a comparative value, and that a Committee be appointed to draw up details of a standard soot and dust-measuring apparatus and methods of its use.
>
> "THAT the Committee do consist of Dr. Des Voeux, Professor J. B. Cohen, B.Sc., Ph.D., F.R.S. (Leeds University), Bailie Smith (Glasgow Corporation), Dr. Hawksley (Liverpool), Dr. John S. Owens, M.D., A.M.I.C.E. (Coal Smoke Abatement Society), Dr. W. N. Shaw, M.A., D.Sc., LL.D., F.R.S. (Director, Meteorological Council), Dr. Vasey ("The Lancet"), and Mr. Kershaw (Hamburg Smoke Abatement Society) with power to add to its number.
>
> "THAT the conclusions and recommendations of such Committee be reported to the delegates forming this Conference and to all municipal authorities in the United Kingdom."

Councillor MUIRHEAD moved, Mr. CLAUDE W. HILL, A.M.I.C.E., M.I.E.E., seconded, and it was unanimously decided

> "THAT this meeting of the delegates of the International Smoke Abatement Conference desires to place upon record its approval of the proposal of Professor C. W. A. Veditz and Dr. R. C. Benner, of Pittsburg University, that steps should be taken to study the economic phases of smoke pollution, and it refers the proposal to the Coal Smoke Abatement Society and the League with the recommendation that an effort should be made to organise in this country action on lines similar to those of the American investigation, in order that the inquiry may possess comparative value."

Bailie SMITH moved :

> "THAT this Conference desires to place on record its conviction that much of the smoke nuisance in connection with industrial works is unquestionably due to inefficient hand firing ; and that as the experience of the Hamburg Smoke Abatement Society on the Continent, of the Coal Smoke Abatement Society at the Borough Polytechnic Institute in London, as well as of such cities as Glasgow, Liverpool, and Manchester, show that stokers are anxious to avail themselves of special instruction calculated to increase their knowledge of their calling, the Conference desires to impress upon local authorities and the directors of technical institutes the importance of establishing classes for the training of stokers and of granting certificates of competency."

Mr. Pearson seconded the resolution, which was carried unanimously after a discussion in which Dr. Day, Mr. Neald, Dr. Owens, and the Secretary took part.

The Chairman moved the following formal resolutions, which were unanimously adopted :

> "THAT the hearty thanks of the delegates of this Conference be tendered to the readers of the twenty-eight papers submitted to the Conference, which papers have contributed so largely to the success of the meetings."

> "THAT copies of the resolutions passed at this Conference be forwarded to the President of the Local Government Board, to the delegates to the Conference, to the Association of Municipal Corporations to this Conference, and to every Municipal Authority in the United Kingdom."

Mr. Nicholson moved a resolution tendering the heartiest thanks of the Conference to Mr. Whitaker.

Dr. Des Voeux seconded the resolution, which was carried by acclamation.

The proceedings closed with a hearty vote of thanks to Dr. Des Voeux, Mr. Chubb, and the Coal Smoke Abatement Society for their services in connection with the Exhibition and Conferences.

THE COAL SMOKE ABATEMENT SOCIETY.

25, VICTORIA STREET, WESTMINSTER, S.W.

Report on Returns by Local Authorities with regard to the carrying out of their Powers and Duties in the matter of Smoke Abatement

BY

LAWRENCE W. CHUBB
F.C.I.S.
Secretary, Coal Smoke Abatement Society

Read at Conference on Smoke Abatement, London, Dec. 12—15th, 1906, organised by THE ROYAL SANITARY INSTITUTE and the COAL SMOKE ABATEMENT SOCIETY.

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REPORT UPON RETURNS FURNISHED BY LOCAL AUTHORITIES WITH REGARD TO THE CARRYING OUT OF THEIR

POWERS & DUTIES IN THE MATTER OF SMOKE ABATEMENT.

By LAWRENCE W. CHUBB, F.C.I.S.,
Secretary, Coal Smoke Abatement Society.

WITH the object of ascertaining to what extent local authorities have grappled with the problem of smoke abatement, all corporations and urban district councils in the United Kingdom have been asked to furnish replies to a series of questions addressed to them on behalf of The Royal Sanitary Institute and the Coal Smoke Abatement Society.

In all, 205 authorities have complied with the request, and from the answers supplied a considerable amount of interesting information may be extracted. While it is true that a feeling of indifference or hopelessness is manifested by a minority of the sanitary authorities, on the whole the reports show that where a local authority resolutely faces the subject of smoke abatement, with a determination to enforce the provisions of the Public Health Acts, it does not often experience insuperable difficulties in minimising, if not in entirely suppressing, black smoke nuisances. At the same time there is a general consensus of opinion that the law should be materially simplified and strengthened.

Indifference of certain Local Authorities.

Of the 205 reports, those received from county councils do not call for special comment, as such councils do not possess urban sanitary powers. Thirty other reports may be summarily dismissed, for the authorities confess that they have either entirely neglected the matter, or that the smoke

evil has not been sufficiently acute in their area to demand attention. It is fair, perhaps, to infer that the many authorities from whom no returns have been received should be placed in the same category. The authorities whose reports may be dismissed as being negative in character are those for the following places: Abertillery, Carnarvon, Colchester, Crewe, Darlington, Devonport, Doncaster, Dover, Dunfermline, Exeter, Harwich, Hereford, Ilford, Ilkeston, Kesteven, Leamington Spa, Llanelly, Maidstone, Oldbury, Reigate, Rochester, St. Albans, Shrewsbury, South Shields, Tipton, Wednesbury, West Bromwich, Wokington, and Woodford.

The inactivity on the part of some of the councils named is evidently due to a fundamental misconception of the subject. The excuse given on behalf of Tipton may be cited as a typical illustration of this assumption. It is said on their behalf that the "council will not take any steps in the matter as they are too glad to have the smoke as an evidence of renewed trade." If every sanitary authority could be brought to recognise that the emission of black smoke is an ocular proof of an avoidable waste of fuel which, as has been abundantly demonstrated, can be remedied to the pecuniary advantage of the employer, as well as to the comfort of the public, they might, perhaps, realise the desirability, from all points of view, of performing their statutory duties in the matter.

It is refreshing to turn from the councils which have displayed no interest in the subject to those which manifest a keen sense of their obligations to the public.

Local Authorities having Special Smoke Inspectors.

The following authorities state that they employ special inspectors with the object of dealing with smoke nuisances:—Bethnal Green, Birmingham (4), Bradford, Croydon, Edinburgh (2), Glasgow (2), Hackney, Hammersmith, Hull, Kings Lynn, Lambeth, Leeds, Liverpool (3), City of London, London County Council, Manchester (5, one being a chemist in whose duties is included the inspection of chemical and other works where chemical or expert knowledge is required), Marylebone, Paddington, Stockport, Salford, Sheffield and West Ham.

In other cases the sanitary officers or inspectors of nuisances are instructed to deal with nuisances arising from the emission of black smoke.

Police Assistance.

The services of the police are utilised by the following authorities:—Alfreton, Ayr, Battersea (occasionally), Bury (where a policeman accompanies an inspector making observations), Cambridge, Devonport, Dun-

fermline, Edinburgh, Gloucester, Gorton, Greenwich (occasionally), City of London (when required), Manchester (casually), Margate, Merthyr Tydfil, Nottingham (police only), Paddington, Paisley (police only), Ramsgate (police only), and Southport (police only).

In the case of Nottingham the co-operation of the police has evidently been of much service, for the corporation recommend an alteration of the law, so that it shall be a special duty of the police to take proceedings in all cases of emission of black smoke.

Time Limits for the Emission of Smoke.

One of the questions addressed to local authorities was:—"Has any hourly or other limit been fixed during which black smoke may be emitted from factories or other works within the area controlled by the corporation?" The Public Health Acts do not define what constitutes a black smoke nuisance. They simply indicate that, where black smoke is emitted in such quantities as to be a nuisance, the nuisance shall be liable to be dealt with summarily under the Acts. It is open to doubt whether any imposition of a time-limit during which black smoke might be emitted with impunity, would be desirable. Nervertheless, it must be admitted that the present state of the law has led to a great deal of confusion, for each authority itself defines what, in its opinion, constitutes a black smoke nuisance, and glaring anomalies naturally exist. For instance, at Leeds the emission of black smoke for an aggregate period of three minutes in an hour is held to be sufficient to justify action, whereas at Middlesborough the period is fixed at fifteen minutes, and at Perth the emission must be *continuous* for eight minutes.

Several authorities have expressed an opinion that the fixing of a time-limit would be both illegal and unwise, but on the other hand a large number point out that it would be far less difficult to obtain a conviction were a fixed time-limit imposed than is the case at the present time, when Magistrates have their own views as to what constitutes a black smoke nuisance.

The following list shows the time-limits adopted by the local authorities indicated:—

(*a*) Authorities which have adopted a half-hourly limit—

Ashton-under-Lyne, 4 minutes; Blackpool, $2\frac{1}{2}$; Gorton, 4; Huddersfield, 3; Manchester, 2; Oldham, 4; Salford, 3; and Warrington, 3.

(*b*) Authorities which have adopted an hourly limit—

Accrington, 8 minutes; Batley, 10; Blackburn—1 boiler, 4; 2 boilers, 5; 3 boilers, 6; 4 boilers, 7; Bolton, 5; Bootle, 6; Bradford, no limit

fixed, but emission of 10 minutes in hour acted upon; Brighton, 10, black, and 20, moderate; Bury, 5, notice sent, and 10, proceedings taken; Cardiff, 5; Chorley, 10; Dewsbury, 12; Eccles, 4, notice sent, and 6, proceedings taken; Enfield, 5; Glasgow, 3 or 4 (moves under special Act); Halifax, 5; Hanwell, 5; Harrow-on-the-Hill, 5; Heywood, 10; Holborn, 2, continuous emission; Keighley, 4; Lambeth, 5; Lancaster, no limit actually fixed, but emissions of 3 minutes reported; Leeds, 3; Leith, 10; Liverpool, 4, continuous emission; Middlesborough, 15; Nelson, 10; Newcastle-upon-Tyne, 5; Norwich, 5; Perth, 8, continuous emission; Portsmouth—1 boiler, 3; 2 boilers, 5; 3–5 boilers, 7; 6 or more boilers, 10; Preston, 10; St. Helens, 5, continuous emission; Stafford, 2, continuous emission; Stalybridge, 10; Swinton and Pendlebury, 5; Wakefield, 10; Wandsworth, 3, continuous emission; Westminster, no limit definitely fixed, but in practice 8 minutes is acted upon; and Wigan, 8.

Increase or Decrease of Smoke.

145 Councils have answered the question "In the opinion of the authority is the emission of black smoke increasing or decreasing within its area?" 25 have replied that an increase has taken place; 80 have stated that in their judgment the evil shows a tendency to decrease, often due to the substitution of gas for steam power; while 40 stated that the nuisance remains stationary.

The returns are as follows:—

(*a*) Authorities stating that the smoke nuisance is *increasing*, 25:—
Blackburn, Batley, Chelsea, Gloucester, Halifax, Harrow, Huddersfield, Ipswich, Limerick, Luton, Maidstone, Morley, Nelson, Newport (Mon.), Nottingham, Perth, Reading, Rugby, St. Marylebone, Stratford, Tottenham, Warrington, Willesden, Worcester and Worthing.

(*b*) Authorities stating that the smoke nuisance is *decreasing*, (80):—
Ashton-under-Lyne, Ayr, Blackpool, Bolton, Barrow-in-Furness, Battersea, Bethnal Green, Bermondsey, Birmingham, Brighton, Bristol, Bury (slightly), Camberwell, Cardiff, Chatham, Carnarvon, Chester, Colne, Coventry, Crewe, Doncaster, Dublin, Dudley, Dundee, Edinburgh, Enfield, Farnworth, Falkirk, Finchley, Finsbury, Gravesend, Greenwich, Hackney, Hammersmith, Holborn, Hove, Hull, Keighley, Kensington, Kidderminster, Kings Lynn, Lambeth, Lancaster, Leeds, Leith, Lewes, Lewisham, City of London, Liverpool, Manchester, Middlesborough, Newcastle-upon-Tyne, Northampton, Norwich, Paddington, Port of London Sanitary Authority, Paisley,

Poplar, Rochdale, St. Helens, Salford, Scarborough, Sheffield, Shoreditch, Stalybridge, Stockport, Stroud, Swinton, Taunton, Wandsworth, Waterloo-with-Seaford, West Ham, Westminster, Wednesbury, Wigan, Winchester, Wood Green, Woolwich and York.

(*c*) Authorities stating that the smoke nuisance remains *stationary*, 40:—Accrington, Alfreton, Bootle, Bournemouth, Bath, Bradford, Bromley, Burton-on-Trent, Cambridge, Chichester, Chorley, Croydon, Darlington, Dunfermline, Eastbourne, Eccles, Ealing, Epsom, Exeter, Gorton, Hampstead, Hastings, Hanwell, Ilkeston, Leicester, Merthyr Tydfil, Oldbury, Oldham, Oxford, Ramsgate, Reigate, St. Pancras, Southampton, South Shields, Swansea, Tipton, Walsall, Watford, Wimbledon and Wokington.

Action taken by Local Authorities.

Councils were asked to state how many smoke nuisances were reported to them during each of the last two years, how many statutory notices were served by them, and the number of prosecutions undertaken. The information supplied on these points is too inadequate to permit of detailed and satisfactory analysis.

The incomplete returns fnrnished by 23 Motropolitan Borough Councils show that 4,353 reports of smoke nuisances were dealt with during the last two years, 897 statutory and 394 intimation notices being served and 61 prosecutions undertaken. The following statement supplied by the Public Control Committee of the London County Council shows the result of the valuable action taken by the Council.

Borough Councils.	Action of the County Councils: No. of reports of nuisance sent to Boro' Councils.		Action of the Borough Councils: No. of cases in which statutory notices were served.		No. of cases in which legal proceedings were taken.		No. of cases in which convictions were obtained.		Amount of penalties imposed.	
	1903–4	1904–5	1903–4	1904–5	1903–4	1904–5	1903–4	1904–5	1903–4 £ s. d.	1904–5 £ s. d.
Battersea	2	1	25	11	2	7	1	7	2 9 0	10 1 0
Bermondssy	1	10	12	11	4	...	4	...	12 18 0	...
Bethnal Green ...	16	8	15	4	1	...	1	...	2 2 0	...
Camberwell	21	4	18	6	2	1	2	...	8 0 0	...
Chelsea	2	2	1	2	...	...	...	...	...	...
Deptford	21	25	4	9	...	2	...	2	...	6 4 0
Finsbury	1	17	14	12	7	5	7	5	22 17 0	24 14 0
Fulham	13	12	8	7	2	...	2	...	15 0 0	...
Greenwich	19	16	7	6	...	1	...	1	...	2 3 0
Hackney	13	9	9	5	3	...	2	...	7 0 0	...
Hammersmith ...	20	9	9	17	1	...	1	...	10 10 0	...
Hampstead	6	1	1	3	...	...	...	...	...	...
Holborn	2	10	5	12	1	1	1	1	2 2 0	4 2 0
Islington	35	80	6	10	2	5	2	5	1 15 0	15 5 0
Kensington	7	4	1	2	...	...	...	...	...	...
Lambeth	55	42	160	46	...	...	...	...	...	...
Lewisham	4	16	...	5	...	2	...	1	...	0 6 0
Paddington	3	6	1	5	...	...	...	...	...	...
Poplar	167	108	81	51	7	3	6	3	14 19 6	13 8 0
St. Marylebone ...	4	17	19	2	...	1	...	1	...	10 0 0
St. Pancras	43	116	24	4	...	...	...	...	...	...
Shoreditch	22	23	...	1	...	...	...	...	...	...
Southwark	23	14	23	11	9	4	9	3	27 0 0	20 0 0
Stepuey	142	85	100	25	6	1	6	1	31 18 0	3 3 0
Stoke Newington	1	1	...	...	...	...	...	...	...	...
Wandsworth	3	14	1	9	...	6	...	6	...	13 4 0
Woolwich	8	12	...	...	3	...	3	...	14 9 0	...
Westminster ...... (City of)	12	30	25	33	4	4	4	4	*30 14 6	18 13 0
TOTALS	666	692	569	309	54	43	51	40	203 14 0	141 3 0

* Also an amount of approximately £50, being the costs of the City Council in an appeal to the High Court in respect of smoke nuisance from club premises.

The returns furnished by 109 provincial authorities are also incomplete. So far as they may be relied upon, however, they show that during the last two years 9,553 smoke nuisances have been reported to the 109 councils; these have led to the issue of 4,059 intimation and statutory notices and to 2,345 prosecutions.

The information with regard to prosecutions undertaken by provincial authorities is misleading, for seven of the authorities are responsible for no fewer than 2,181 of the proceedings, leaving only 164 prosecutions undertaken in two years by the remaining 102 authorities. The city of Liverpool, which moves under a special local Act and not under the Public Health Act, 1875, undertook 643 prosecutions in 1903 and 615 in 1904,

being successful in 633 and 602 cases respectively and receiving in fines £2,466 12s. 2d., an average of about £2 per case. Of the other authorities, Manchester initiated 277 cases, Glasgow 226, Birmingham 178, Bradford 111, Nottingham 69 and Sheffield 62.

One of the most disquieting features manifested by the information supplied under this head is the small percentage of cases in which statutory notices have been served and subsequent proceedings initiated by local authorities. In the provinces, after deducting the cases dealt with by the 7 authorities referred to in the preceding paragraph, there still remain 6,182 reports of black smoke nuisances. In 2,087 instances letters of caution or statutory notices have been served, and apparently the letters of caution far exceed the statutory notices in number. Only 164 prosecutions were undertaken. In the metropolis only 897 statutory and 394 intimation notices were issued in respect of 4,355 cases and the prosecutions amounted to 61. It is obvious that if local authorities do not follow up reports of smoke nuisances by serving statutory notices and initiating legal proceedings the nuisances are not likely to be abated. Several councils state, in extenuation of their inaction, that it is hopeless to secure a conviction as the members of the Bench adjudicating are themselves often offenders in the matter of smoke nuisances!

Smoke Nuisances in adjoining Districts.

A considerable number of local authorities complain of black smoke nuisances arising in the area of adjoining authorities, but the only councils which appear to have moved in such cases, either by written complaints, by serving statutory notices, or by initiating proceedings, are Batley, Brighton, Ealing, Enfield, Hammersmith, Huddersfield, Kensington, Lancaster, the City of London, Manchester, Salford, Shoreditch, Stretford, Stroud, Swinton and Pendlebury, and Westminster.

Methods of Identification of Black Smoke.

In order to ascertain the means adopted for the identification of black smoke, local authorities were asked: "Is any standard or scale used to identify the density of smoke? If not, what method of scheduling or identification is adopted?" The replies disclose that the general rule is to permit the inspectors taking observations to act upon their own judgment. Most of the important corporations provide their officers with special sheets on which to record, in graduated columns, the density of smoke emitted, and in some cases observations are made jointly by two inspectors. The following authorities treat as black all smoke which cannot be seen through when it emerges from the chimney: Ashton-

under-Lyne, Blackburn, Bury, Chorley, Epsom, Farnworth, Halifax, Heywood, Oldham, Preston, Rochdale, St. Helens, Southampton and Stretford. Eccles, Liverpool and Newcastle-on-Tyne consider smoke black when it is opaque after it has travelled a few yards; Huddersfield and Norwich when the lightning conductors cannot be seen through it; and Falkirk when the top of the chimney cannot be seen through it. Several authorities supply their officers with sheets illustrating various shades of smoke. Among these, Coventry, St. Marylebone and Willesden use the diagrams issued by the Coal Smoke Abatement Society; Cardiff, Hammersmith, Reading and Woolwich use Ringlemann's Smoke Scale, and Bournemouth has adopted the method of identification advocated by Messrs. Sanderson & Clayton. St. Pancras, Battersea, Manchester, the City of London, the London County Council, and the London Port Sanitary Authority have specially prepared and shaded diagrams for the use of their inspectors; and Westminster uses the scale adopted by St. Pancras. Photography is employed, as an accessory to the inspector's personal observation, by Bradford, Holborn and Hull; and the Glasgow Corporation state: "The term 'black smoke' is defined as smoke containing 281 lbs. of solid matter per million cubic feet discharged, light brown smoke containing only 20 lbs. of solid constituents."

Proposed Amendments of Law.

Local authorities were further asked whether, in their opinion, any amendments were needed in the law with regard to the suppression of black smoke nuisances. Fifty-six have expressed no opinion upon the desirability of any change being effected in the law with regard to the abatement of smoke, and only two have indicated their satisfaction with the law as it at present stands. On the other hand this question elicited a number of helpful suggestions, of which the following are perhaps the most useful.

The proposed amendments mainly deal with Clause 91 of the Public Health Act, 1875, the clause which declares a chimney (not being a chimney of a private dwelling house) emitting "black" smoke, to be a nuisance within the meaning of the Act. Owing to the difficulty of obtaining the requisite technical evidence to secure a conviction under the alternative provision of the Act designed to prohibit the use in trade premises of a furnace so constructed as not to consume its own smoke, practically all prosecutions issued by local authorities with the object of securing the suppression of smoke nuisances are taken under the section prohibiting the emission of black smoke.

The following local authorities advocate the omission of the qualifying word "black" from the section, in order to enable proceedings to be instituted in cases where smoke emitted is actually a nuisance though not "black" in colour: Blackpool, Cardiff, Chelsea, Epsom, Lambeth, and Sheffield. The authorities advocating the substitution of the word "dense" for "black," are Keighley, Nelson (or delete "black"), and Stretford (and delete words "as far as practicable").

The Coal Smoke Abatement Society has at various times carefully considered the desirability of amending Section 91 of the Public Health Act, and has come to the conclusion that it would be inadvisable to delete the word "black," as proof of the sustained emission of black smoke is (or should be) at present sufficient to secure a conviction; it has also felt that the substitution of the word "dense" for "black" would only remove one technical difficulty to create another. It, however, has suggested that the section would be materially strengthened if it were broadened to permit of prosecutions in respect of smoke of any colour emitted in such quantities as to be a nuisance. All that is needed to secure this desirable amendment is the insertion in Section 91 of the Public Health Act, 1875, and in Section 24 (*b*) of the Public Health (London) Act, 1893, after the words "black smoke," of the words "or other smoke." It is interesting to note that this proposal is also made on behalf of Cardiff, Enfield, Greenwich, Hammersmith, Kensington, the London County Council, Paddington, Westminster, and Wood Green. Liverpool suggests the substitution of the words "excessive and unnecessary" for "black."

As has been already indicated, several authorities allude to the difficulty they experience in obtaining a conviction owing to the fact that the Magistrates before whom the proceedings take place are themselves black smoke offenders. They therefore press for the appointment of Stipendiary Magistrates, who might be relied upon to have no personal bias on the question.

The lowness of the penalties imposed upon the conviction of offenders is frequently commented upon, and several authorities urge that the penalties should be materially increased for the first offence and automatically raised on subsequent conviction, in order to make it imperative on the part of the manufacturers to abate smoke nuisances. It is pointed out that where penalties are not sufficiently large to act as a deterrent, offenders prefer to run the risk of further convictions rather than adopt means to abate the emission of smoke. It is also suggested that magistrates should inflict a penalty when an abatement order is issued. On this point

the Public Control Committee of the London County Council has recommended the alteration of the law, by the imposition of a direct penalty of not exceeding £10 for the first offence, increasing for subsequent offences, instead of applying to smoke nuisance, as at present, the complicated procedure that may be properly applicable to a sanitary nuisance. Bolton, Bootle, Bradford, Northampton, Salford and Willesden are amongst the other authorities which urge that increased penalties should be provided for.

It is further suggested that Parliament should be invited to fix a definite hourly time-limit for the emission of black smoke,—proof of the limit having been exceeded to be sufficient to secure a conviction. The local authorities urging this amendment are those for Dundee, Keighley (four minutes per hour suggested), Kidderminster, Lancaster, Luton (fifteen minutes per hour suggested), Stroud, Tottenham, and Wood Green.

Another interesting proposal is that put forward by the Chelsea Borough Council, on whose behalf it is pointed out that a great deal of offensive black smoke is emitted from the chimneys of the large mansions and flats in the district. It is suggested that the law should be amended to enable such nuisances to be dealt with.

Other suggestions are that the delay arising from the present complicated procedure, which involves the service of statutory notices, should be obviated by the giving of power to the Medical Officer of Health to summon forthwith on the detection of a nuisance; that the police should be empowered to initiate proceedings; that a definite scale or standard should be provided for the identification of smoke; that firemen should be dealt with and fined when proper appliances and proper coal are found (this is done under a local Act at Nottingham); that factory inspectors should be appointed by a Government department; that the prohibition against the emission of black smoke should be applied to property in possession of the Crown—a proposal adopted at a Conference of Metropolitan Borough Councils, and endorsed by the London County Councils; and that provision should be made for the infliction of heavier penalties in cases of black smoke emitted from locomotives on highways or railways.

Authorities with Special Powers to deal with Smoke Nuisances.

The following Authorities state that they initiate proceedings for the abatement of smoke nuisances under Special Local Acts of Parliament and not under the Public Health Acts:—Birmingham, Coatbridge, Edinburgh, Glasgow, Leeds, Leicester, Liverpool, Nottingham and Oldham. Particulars of the special powers conferred upon these authorities have un-

fortunately not been supplied by all. In the case of Leeds, however, the powers given to the Corporation by the Leeds Improvement Act, 1866, appear to be very stringent. Section 77 of the Act provides for the infliction of penalties in regard to every furnace which has not been "constructed or altered as to consume or burn the smoke arising from such furnace," or which is negligently used. Power is also given for the suppression of *any* smoke nuisances within the Borough and the Smoke Inspector appointed under the Act is directed to summarily prosecute in all cases of smoke nuisance without any authority from, or reference to, the Council of the Borough.

The Nottingham Corporation proceeds under the Nottingham Improvement Act, 1874, which enacts that "If any fireplace or furnace employed in the working of engines by steam, or in any building used for the purpose of trade or manufacture, or baths or washhouses (although a steam engine is not used therein) and is not so constructed as to prevent or burn the smoke . . . . the owner . . . . . shall be liable to a penalty not exceeding £10 and a further penalty not exceeding 40s. for every day during any part of which any fireplace or furnace is so employed." The negligent use of fireplaces or furnaces is liable to like penalties, and the Corporation is given power to proceed against "any engineer, fireman, stoker, foreman, or other person," who by negligently using a furnace is liable to a penalty of 40s.

Conclusion.

To sum up, the returns disclose that while the black smoke evil is very generally felt and deplored, relatively few local authorities have in the past taken a decided stand in the matter, and that while this inactivity may sometimes be traced to apathy, it is more often due not to any inclination to evade responsibility, but to a feeling of hopelessness in view of the uncertainty of obtaining convictions. Where authorities have taken a decided stand, however, even with the imperfect machinery at present available for the suppression of smoke nuisances, it is only fair to say that they claim to have diminished the evil. Little improvement or zeal can be looked for until the law is simplified and extended, and a more summary and effective method of procedure provided. It is, perhaps, not too much to hope that the Local Government Board, in view of the suggestions made by important corporations, may see its way to clothe local authorities, in the immediate future, with the further powers for which they ask.

CONFERENCE ON SMOKE ABATEMENT,

ARRANGED BY

THE ROYAL SANITARY INSTITUTE

IN CONJUNCTION WITH

THE COAL SMOKE ABATEMENT SOCIETY,

TO BE HELD IN THE

ROYAL HORTICULTURAL SOCIETY'S HALL,

VINCENT SQUARE, WESTMINSTER,

FROM DECEMBER 12th to 15th, 1905.

SECRETARIES:

E. WHITE WALLIS, F.S.S.

PARKES MUSEUM, MARGARET STREET, LONDON, W.

LAWRENCE W. CHUBB,

25 VICTORIA STREET, LONDON, S.W.

EXHIBITION OF
SMOKE ABATEMENT APPLIANCES,

TO BE HELD AT THE

ROYAL HORTICULTURAL SOCIETY'S NEW HALL,

VINCENT SQUARE, WESTMINSTER,

From TUESDAY, DEC. 12th, to FRIDAY, DEC. 15th, 1905.

The Exhibition is held in connection with the Conference on Smoke Abatement, arranged by the Council of The Royal Sanitary Institute and the Coal Smoke Abatement Society, and will include grates, stoves, cooking plant, heating flues, chimney construction, and smoke consuming and preventing appliances.

Delegates are being invited to the Conference from Municipal Authorities throughout the kingdom, and the Meetings **will be held in the same Hall as the Exhibition**, so that all visitors will have an opportunity of seeing the Exhibits before and after the discussion, and during the intervals.

Applications for Space must be made on the Official Form, which must be sent to the Offices of The Royal Sanitary Institute, Margaret Street, London, W., not later than Saturday, November 11th.

The Scale of Charges for Floor Space will be 10s. per foot frontage, with a depth of six feet. Special terms will be arranged for Exhibits requiring a large amount of space. Wall Space, 1s. per square foot. *All charges must be paid at the time of allotment.*

Silver and Bronze Medals will be awarded at the discretion of the Judges, and their decisions will in all cases be final. A Classified List of all Awards is published by the Institute.

Protection in accordance with the Patents, Designs, and Trade Marks Act, 1883, will be obtained from the Board of Trade for persons desirous of Exhibiting New Inventions.

Loan Collection. The Committee invite and will be pleased to receive any Drawings or Photographs showing construction ef Smoke Abatement Appliances.

Forms of Application for Space and other Particulars can be obtained at the Offices of The Royal Sanitary Institute, Margaret Street, London, W.

Conference on Smoke Abatement,

DECEMBER 12, 13, 14, and 15, 1905.

A CONFERENCE AND EXHIBITION ON SMOKE ABATEMENT has been arranged by The Royal Sanitary Institute and The Coal Smoke Abatement Society to be held in London, on December 12th, 13th, 14th, and 15th, 1905.

The question of the Abatement of Smoke and its attendant evils in large towns, including the reduction in daylight and sunshine, has an important bearing on the Public Health. In addition to the prevention of smoke from factories, much can be done to reduce the volume of smoke from dwellings, which in the aggregate amounts to as much as that from factories, by furthering the use of Gas and Electricity and Smokeless Fuel, and encouraging improved forms of Stove and Grate Construction.

In order to discuss the various ways in which this important problem can be approached, The Royal Sanitary Institute and The Coal Smoke Abatement Society have arranged a Conference, to which they are inviting delegates from the various Authorities and Public Bodies.

The subjects arranged for Discussion are set out in the Programme for each day (pages 5, 6, 7).

The EXHIBITION arranged in the GREAT HALL will be open each day to those attending the Conference from 10 a.m. to 8 p.m.

PAPERS AND DISCUSSIONS.

Proofs of papers and notes of points to be brought forward in discussion will as far as possible be issued beforehand, as this arrangement has been found most advantageous in securing practical and useful discussions.

All papers will be taken as read. Openers of discussions will be allowed fifteen minutes to introduce the main arguments of the paper, and subsequent speakers will be allowed ten minutes each.

A short abstract must accompany every Paper, both for the convenience of the Press at the Conference and for insertion, subject to

the approval of the Council, in the Journal of the Institute, should it not be deemed desirable to publish the paper *in extenso*. No previously published Paper can be accepted. The acceptance of Papers, and the days on which they are to be discussed, are determined by the Council before the beginning of the Meeting. The Council reserve the right of refusing any Papers sent in; and in the case of those accepted, the discussion of them must depend on the time at the disposal of the Meeting. Papers accepted for the Conference cannot be published by the Authors, except by permission of the Council. The Council reserve to themselves the privilege of printing any paper either whole or in part, or of refraining from the publication thereof if they see fit.

Authors should forward their manuscript by post *as early as possible, and in any case not later than November 18th*, addressed to the Secretary, Royal Sanitary Institute, Margaret St., London, W.

REFRESHMENTS.

Arrangements have been made by which light refreshments can be obtained in the Building.

RESOLUTIONS.

Resolutions put from the Chair at the Meetings must only be in the form of recommendations to the Council of the Institute, by whom all such recommendations will be carefully considered. The number of persons present, and the proportions voting, must be recorded by the Chairman for the information of the Council.

No Resolution can be proposed unless *sent to the Secretaries in time for approval before the day on which it is to be proposed.*

TICKETS.

Fellows, Members, and Associates of the Institute, and Members of The Coal Smoke Abatement Society, are supplied with Tickets on application to the Secretary before the Conference, or they may be obtained at the Conference Room during the Meeting.

To those not connected with either Society, Conference Tickets will be issued, entitling the holder to admission to the Presidential and other Addresses, to all Meetings, to the Exhibition, and to copies of the Monthly Journal of the Institute containing the proceedings of the Conference. The price of the Conference Tickets is 10s. 6d. each. These Tickets may be obtained at the Offices of The Institute, 72, Margaret Street, London, W.

OFFICERS OF THE CONFERENCE.

President.

SIR OLIVER LODGE, F.R.S., D.Sc., LL.D.,

Principal of the University of Birmingham.

Vice-Presidents.

SIR JOHN URE PRIMROSE, Bart.
SIR WILLIAM H. PREECE, K.C.B., M.INST.C.E., F.R.S.
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TUESDAY, DECEMBER 12th, 1905.

INAUGURAL MEETING OF THE CONFERENCE AND OPENING OF THE EXHIBITION.

The Chair will be taken at 8.30 p.m. by

HIS GRACE THE DUKE OF FIFE, K.T., P.C., D.L.,

In the Horticultural Society's Hall.

Presidential Address

By

SIR OLIVER LODGE, D.Sc., LL.D., F.R.S.

Subject:

"THE GENERAL PROBLEM OF COMBUSTION REFORM."

WEDNESDAY, DECEMBER 13th, 1905.

SUBJECT FOR THE DAY:

"DOMESTIC SMOKE ABATEMENT."

Chairman:

SIR GEORGE LIVESEY, M.INST.C.E., M.I.M.E.

11 a.m.—

Papers by:

H. A. DES VŒUX, M.D.
"The Abatement of Smoke from Private Houses."

A. S. E. ACKERMANN, B.SC.ENG., A.C.G.I., A.M.INST.C.E.
"The Distribution of Producer Gas as a means of alleviating the Smoke Nuisance."

SIR CHARLES COOKSON, K.C.M.G., C.B.
"Coke (Charred Coal) as a Domestic Fuel."

MISS M. AGAR (Metropolitan Gardens Association).
"The Effect of Smoke on Plant Life."

PROF. J. B. COHEN, PH.D.
"A Record of the Work of the Leeds Smoke Abatement Society."

S. RIDEAL, D.SC., F.I.C.
"The Acids of Smoke."

And general discussion is invited.

The order in which the papers are to be read will be given in the Daily Programme.

---

1 p.m. Luncheon.

Visit to

Chelsea Generating Station of the Underground Electric Railways Co. of London, Ltd.

Meet at the Station at 2.30 p.m.

THURSDAY, DECEMBER 14th, 1905.

SUBJECT FOR THE DAY:

"FACTORY & TRADE SMOKE ABATEMENT."

Chairman:

SIR WILLIAM H. PREECE, K.C.B., M.INST.C.E., F.R.S.

11 a.m.—

Papers by:

COMMANDER W. F. CABORNE, C.B., F.R.A.S., F.R.G.S., F.R.MET.SOC.
"Stoking and Smoke Abatement."

S. RIDEAL, D.SC., F.I.C.
"Report based upon Returns furnished by Manufacturers who have succeeded in securing the Abatement of Smoke in Factories."

JOHN B. KERSHAW, F.I.C.
"The Aims and Work of the Hamburg Smoke Abatement Society."

JOSEPH W. LOVIBOND.
"The Precautions necessary for making Reliable Observations of Smoke Densities."

And general discussion is invited.

The order in which the papers are to be read will be given in the Daily Programme.

---

1 p.m. Luncheon.

Visit to

Gas Works of the South Metropolitan Gas Co., Old Kent Road.

Meet at Works at 2.30 p.m.

FRIDAY, DECEMBER 15th, 1905.

SUBJECT FOR THE DAY:

"ADMINISTRATION, LEGISLATION, AND NECESSARY REFORMS."

Chairman:

SIR WILLIAM B. RICHMOND, K.C.B., R.A., L.C.C.

11 a.m.—

Papers by:

JULIAN S. CORBETT, LL.M., F.S.A. (Barrister-at-Law).
"Note on the Proposed Amendment of Section 24 (Sub-Section 6) of the Public Health Act (London) 1891."

JOSEPH HURST (Barrister-at-Law).
"English Law relating to the Emission of Smoke from Chimneys."

SIR JOHN URE PRIMROSE, Bart.

LAWRENCE W. CHUBB (Secretary, Coal Smoke Abatement Society).
"Report upon Returns furnished by Local Authorities, with regard to the carrying out of their powers and duties in the matter of Smoke Nuisances."

HON. ROLLO RUSSELL, M.A., F.R.MET.SOC.
"The artificial production of Persistent Fog."

ARTHUR RIGG (on behalf of the Royal Botanic Society of London).
"The Deleterious Effects of Coal Smoke on Plants growing in the Gardens of the Royal Botanic Society of London."

W. N. SHAW, M.A., D.SC.
"Is London Fog inevitable?"

T. G. DEE (Sanitary Inspector, Westminster).
"Smoke Abatement from the Sanitary Inspector's point of view."

And general discussion is invited.

The order in which the papers are to be read will be given in the Daily Programme.

---

1 p.m. Luncheon.

Visit to

Abbey Mills Pumping Station, London Sewage Outfall Works.
Meet at Station about 2.30 p.m.

LIST OF AUTHORITIES WHO HAVE UP TO THE PRESENT APPOINTED DELEGATES TO THE CONFERENCE.

Birmingham.
Blackburn.
Bournemouth.
Bristol.
Civil and Mechanical Engineers Society.
Croydon.
Darlington.
Dartford.
Edinburgh.
Fulham.
Hackney.
Holborn.
Incorporated Association of Municipal and County Engineers.
Incorporated Society of Medical Officers of Health.
Institution of Gas Engineers.
Institution of Mechanical Engineers.
Kingston-on-Thames.
Lancashire C.C.
Leicester.
Liverpool.
London.
London (Port Sanitary Authority of).
Nelson.
North of England Institute of Mining and Mechanical Engineers.
Norwich.
Paddington.
Poplar.
Portsmouth.
Reading.
Richmond.
Rochester.
Royal Institute of British Architects.
Salford.
St. Helens.
Southall-Norwood.
Stoke Newington.
University College, London.
University of Glasgow.
University of Leeds.
Victoria University of Manchester.
Watford.
Walthamstow.
Wandsworth.
West Riding C.C.
Wigan.
Wimbledon.
Worcester.

EXHIBITION OF SMOKE ABATEMENT APPLIANCES

HELD IN CONNECTION WITH THE CONFERENCE.

CLASSIFICATION OF EXHIBITS.

SOLID FUELS.

Various Forms.
Heating Appliances.
Cooking Appliances.
Trade and Municipal Appliances.

OIL FUELS.

Various Preparations and Mixtures.
Heating Appliances.
Cooking Appliances.
Trade and Municipal Appliances.
Lighting.

HOT WATER AND STEAM.

Boilers.
Radiators and Appliances for Heating Buildings.

GAS.

Installations for Domestic Manufacture.
Heating Appliances.
Cooking Appliances.
Trade and Municipal Appliances.
Lighting.

ELECTRICITY.

Apparatus for Small Installations.
Heating Appliances.
Cooking Appliances.
Trade and Municipal Appliances.
Lighting.

TESTING APPLIANCES.

Thermometers.
Pyrometers.
Meters.
Gauges.
Tintometers.

DOMESTIC DESTRUCTORS AND REFUSE CONSUMERS.

MODELS, PHOTOGRAPHS, & DRAWINGS.

SMOKE ABATEMENT.

PAPERS

read at the

Smoke Abatement Conferences

at

SHEFFIELD, MARCH 1909,

with

An Address delivered by

SIR OLIVER LODGE

at the Opening of the Exhibition.

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PAPERS READ

at the

Smoke Abatement Conferences

held in the

CORN EXCHANGE, SHEFFIELD,

MARCH 3rd, 8th, and 13th, 1909,

with

An Address

delivered by

SIR OLIVER LODGE

At the Opening of the Smoke Abatement Exhibition.

CONTENTS.

INTRODUCTION.

As several of the addresses given were unwritten and only briefly reported in the Press, the Committee of the Smoke Abatement Exhibition consider it desirable to give a short summary of general conclusions that may fairly be derived from the Exhibition and the Public Conferences.

The Exhibition brought together the latest inventions and appliances ; the Conferences, the results of the most recent experiments in smoke prevention carried out by practical scientifically trained men. To what conclusions do these two definitely point ?

To the possibility of a striking reduction of the smoke nuisance, with a corresponding saving of fuel. (With regard to the latter a Commission on Coal Supply estimated that 50 million out of the 150 million tons of coal annually consumed in this country could be saved.) Indeed, if all manufacturers attained the level reached by the very best, the atmosphere of our large manufacturing towns would be completely transformed. Of this fact Sheffield itself is a striking example. As a result of the efforts already taken to reduce the smoke nuisance the city in 1907 enjoyed more sunshine (1,428 hours) than any other large town in Great Britain.

Briefly, it may be said that the Exhibition and Conferences demonstrated—

1. That smokeless power producers, such as gas and electricity, are a great advantage.

2. That a number of smoke prevention appliances now on the market give satisfactory results in an economical manner.

3. That there is no necessity for black or even dense smoke from boilers under normal conditions.

4. That 80 per cent. of the black smoke from high temperature re-heating furnaces could be prevented without interfering with the working of the metal.

5. That striking results have been secured by the employment of specially trained stokers giving their whole time to the work.

6. That a great reduction in the amount of smoke produced by domestic fires could be obtained by the adoption of improved fire-places and smokeless fuels.

7. That from the public health point of view the following reforms are urgently needed:—

(a) A change in the wording of the smoke section of the Public Health Act of 1875, which would enable local authorities to take action against smoke of any colour so dense as to be a nuisance, unless it could be proved that such smoke was absolutely necessary.

(b) Power to deal with domestic fires.

(c) The appointment of a Smoke Abatement Department under the Local Government Board, with a staff of expert inspectors to compel defaulting local authorities to do their duty, as at present 90 per cent. of the local authorities take no action to reduce the smoke nuisance.

The Exhibition Committee also desires to express its warm thanks to Sir Oliver Lodge and the other speakers for permission to publish their addresses, and for the trouble they have taken in preparing them for publication.

SCIENCE AND SMOKE.

Sir Oliver Lodge's Ideal.

OUR BARBARIC FIRES. **Striking Sheffield Exhibition.**

Sir Oliver Lodge, the eminent Principal of the Birmingham University, visited Sheffield on March 3rd, 1909, when he performed the opening ceremony of the Smoke Abatement Exhibition at the Corn Exchange. The distinguished visitor, as well as the occasion of the visit, attracted a large attendance.

Sir Charles Eliot, Vice-Chancellor of Sheffield University, presided, others present including the Lord Bishop of Sheffield (Dr. Quirk), Sir Robert Hadfield, Professor Moore-Smith, Professor Lloyd, Mr. W. Sinclair (President of the Association), Mr. W. Bashforth (Secretary), Mr. S. E. Fedden, Councillors Benson, Bescoby, Appleyard, Knowles, Crowther, and Barton, and several ministers.

The Chairman, referring to the Sheffield University's connection with the Exhibition, smilingly admitted that the institution had a chimney which had been reproached several times for making more smoke than it ought. (Laughter.) All he could say in defence was that they had done their best to stop it. A more creditable connection, however, was that it was owing to a lecture by the University's Professor of Chemistry, Professor Wynne, on fogs and the methods of preventing them, that the society and the exhibition were formed.

Travelling through the manufacturing districts of England, one was sometimes tempted to suppose that hitherto very much had not been done to stop the smoke, but it was something to know that energy and science were being expended on correcting the disadvantages which at present attended our industries. Speaking not as an expert, he remarked that there seemed to be two methods of minimising the present disadvantages. One was to substitute for coal as used at present some other power-pro-

ducing agent which did not deteriorate the air to the same extent. The other was to use coal in such a way that it should produce less smoke, and he was told that the process was not only purifying to the air, but that it could also be made economical. Alluding to Sir Oliver Lodge as one of the most " brilliant and versatile of our men of science," he remarked it was nearly thirty years since he commenced his experiments and researches on this subject.

Sir Oliver Lodge, who was greeted with applause, said he stood there as substitute for Sir William Richmond, whose absence through temporary illness they all regretted. For he was President and indeed founder of the London Smoke Abatement Society, and had devoted an admirable amount of energy and interest and time, which might have been given to art, to this subject. It might seem surprising that an artist should specially interest himself in the subject of the purification of the air ; but they must remember that artistic works were very dependent upon atmosphere, and that art itself must depend upon the condition of society in which it tried to flourish. Architecture, for instance, could not be much superior to the general consensus of opinion and stage of culture which a society or a city had reached. He expected that every city, every nation, had the architecture which it deserved. (Hear, hear.) We did not seem to deserve quite so highly in art, in sculpture, in architecture as, let us say, the Greeks, and the reason, he was afraid, must be sought in some defects in our society, our mode of looking at things, and what we thought most worth while. It was this kind of feeling which had turned the attention of many artists to the conditions of social life. It was this which so greatly influenced Mr. Ruskin—who was keenly interested in Sheffield, as they all knew—and turned his attention from his proper work to social problems—(hear, hear)—and led him to deal with those problems in a revolutionary and striking manner which created ridicule and opposition at the time, but which had laid the foundation for a wholesomer and saner and more humane political economy of the future. (Applause.) He showed that the old attempts at economy were leaving out a very important part of the subject, that they were leaving out a great part of human nature. And when that was taken into account he felt it impossible to deal with art alone. He found it necessary to deal with the whole of human nature and the conditions of society in which that art should flourish. He was not content that a few cultivated people should be able

to produce works of beauty. He wanted everybody to live among and to use works of beauty, so that they might become a part of life and not merely a decoration on the walls. This was his aim. This was why he wrote "The Seven Lamps of Architecture," why he urged that architecture was built not upon a knowledge of materials alone, not upon designs of beauty alone, but upon such things as justice, mercy, righteousness, honour, and truth. (Hear, hear.)

When they considered life as it was, and life as it might be, they were struck with the contrast. They were conscious of a feeling, not of despair, but of hope, for the future of the race. For so many people now were realising that life as it was was not as it ought to be, that all this squalor, this extreme of poverty, dirt, and smoke, and other things among which we were content —more or less content—to live, was not the intended and necessary condition of the planet, not the condition which the human race ought to put up with, but a condition which they themselves had brought about, and which they themselves could mend. (Hear, hear.) "The earth is beautiful in the extreme," said Sir Oliver, amid applause, "in places where nobody lives; but in places where people have decided that they wish to live in large numbers together for social purposes, for business purposes, for convenience of all kinds, there they have taken no precautions to keep the earth beautiful, there they have made it ugly, there they have spoilt the face of the earth." Indeed, one of the things a speculative builder sometimes did when he was going to run up houses for the people was first to cut down all the trees and make a wilderness. That was a terrible state of things. It was not so in every country. Switzerland would not be beautiful if they cut everything down before they built their chalets. Every cottage was a thing of beauty, a part of the landscape; it had individuality, and was erected by the owner for his use, it and would make a vast difference to the English race if that could be said of us. To an artist the state of ugliness must be painful, and if it was not painful to others it was because they were to some extent losing their sensibility, which was a serious thing to lose. (Hear, hear.)

It was commonly thought that Mr. Ruskin was against science and engineering. This was a mistake. In many respects he had a keen scientific interest, and in one of his writings he explained how he loved the steam engine, enjoyed seeing it at work, how he

used to stand and watch even the locomotives—until they began to scream—(laughter)—and then he ran away from them. He couldn't stand that. And the same with all other things in machinery. He objected to machinery only when it was put to wrong use, when it was used to produce works of so-called art. Works of art turned out by machinery were worth nothing. They were not artistic, they had no humanity or personality about them. So he said, and he was a good judge. It was this wrong use of machinery and a similar wrong feeling about science that Ruskin did not like. He did not always express himself wisely, and he nearly always expressed himself violently, on these subjects. But his teaching was that what science half-known had done much to disfigure, better known it could only beautify and adorn. (Applause.)

It was an object, proceeded Sir Oliver Lodge, of the kind of exhibition which he was opening, to try and amend those conditions under which, to some extent, we were suffering from misapplied, or ill-applied, or rather, half-applied scientific processes. In the case of smoke, it was usual to say that smoke was wasteful, and it necessarily meant imperfect combustion. But if that was all that had to be said then the self-interest of manufacturers would lead them to take great pains to stop it, but the unfortunate fact was that smoke in practice was not wholly wasteful. There were conditions when it was economical. He was sorry to say it, but so it was. It was economical when they had a variable load and wanted to bank up their fires and wait—without doing much work for a time. It was also economical when they had to heat water or to anneal iron plates or armour-plates, or in any case to heat cold surfaces by means of flame. Then a smoky flame was more efficient than a non-smoky flame, a luminous smoky flame was better than a non-luminous one, for that purpose, under present boiler conditions. The Professor went on to elucidate the principle that it is impossible to bring a flame into contact with a cold surface, and that combustion is consequently imperfect. The heat has to cross a thin film of unburnt gas by radiation. That, he said, was the real difficulty in heating boilers or annealing armour-plates. They must depend upon radiation in the long run. But those conditions could be improved. One remedy was to have studs or projections on the boiler plates which would get red-hot in the flame, and carry the heat in by conduction.

It had been applied to kettles. A kettle with a thick bottom, so that the bottom can get red hot, would be more efficient than one with a thin bottom. Another method was to recognise that they had to deal with radiation and to set to work to arrange for effective radiation. There was a better way than burning coal gas as it was, and trusting to the radiation from the carbon in the flame to give the amount of light required. He instanced the use of the mantle, by which one does not depend upon the carbon at all but uses a smokeless blue flame and puts in a mantle of such substance as will get extremely hot and then radiate powerfully. Something on that principle might be applied to boiler heating, so as to depend not on the hot gases alone—though on them too—but to have real radiating solid surfaces to send the heat into the boiler, and not to have any more smoky flame to do it in an imperfect manner.

For effective radiation high temperature is essential. Radiating power varies as the fourth power of the absolute temperature —whose zero is 490° below zero Fahrenheit. This is an exact statement, and consequently of two surfaces, one at boiler temperature—say 260°F.—and another at red heat—say 1,010°F.— and another at white heat—say 2,510°F. The radiating powers would be the proportion of 1, 16, 256 respectively. The white hot surface thus radiates actually 256 times as strongly as the same surface at boiler temperature.

After then showing how enormously radiating power increases as the temperature rises, Sir Oliver Lodge had something to say about domestic heating. Hot air, he pointed out, was not the best method, though very good as a supplementary method. The ideal was a combination plan—radiation (that was to say, the open fire method) and pipes, or the hot air method. "Heat," he said, "the passages, by warm air, have open fires to give radiating heat into the rooms and to draw the warm air from the passages—or from special flues—into them." Many improved fireplaces had been made upon that combination plan, "so that you are not merely drawing in cold air and making a draught— the open fire does make a draught—and being roasted on one side and chilled on the other."

Ordinary coal fires were very imperfect things indeed. They gave some radiation, but they also gave a great amount of trouble and some dirt; and the combustion was extremely imperfect. A great deal of unburnt gas went up the chimney. A coal fire

was making gas in the first instance and then burning it. It was an imperfect gas fire. "You make gas on the premises and make it badly, in a coal fire. You distil a lot of it up the chimney, and comparatively little heat goes into the room. You have also to stoke the fire at intervals and interrupt your work. Then you have the ashes to rake out, besides the trouble of laying the fire in the morning and carting the coal and dumping it into the coal cellar, and carrying it about the house." "All that is very primitive," commented the scientist smilingly, "a savage could burn coal like that. It is not quite appropriate to the twentieth century."

A better method was to separate the coke and the gas purposely, and then in the houses burn the gas. He was convinced that they would have cheap gas laid on in large quantities for heating and cooking purposes, and that they would depend very much more upon gas in the future—electricity for lighting, gas for heating and cooking. Not the ordinary gas fire. It might be that there was some improved gas fire at that exhibition that he did not know of. Gas fires had greatly improved in the last ten years or so. But he did not suppose that any of them would be considered perfect 20 years hence. If we all burnt purified gas the atmosphere of the towns would be very different from what it was. (Applause.)

And he only hoped that some day some town or other in England would try the experiment of having the gas made at the coalpit—where coal was very cheap—and bringing it in pipes instead of in trucks and carts, bringing the combustible matter in pipes as it now brought water and electricity, forbidding the importation of crude coal into that town at all, and supplying a great quantity of gas at a very cheap rate, and using it for all purposes. If one town would do it as an experiment, then if it was successful, other towns would follow the example. He hoped to live to see that accomplished. (Applause.) One or two towns, he believed, were already thinking about it. In the British Isles we thought about things a great deal before we did them. (Laughter.) There were so many vested interests. There were certainly people who liked fog because it was profitable, but it was wasteful for the community, and was wasteful to human life and health. There were a great many things that could be done to improve life, and the purification of the air was one of them. The atmosphere that we lived in was not the atmosphere in

which our history had been made, and our history now seemed to be getting smoky and foggy. (Laughter.) The issues did not seem quite so clear. Still the times were hopeful. People were realising that things were wrong, and that they had got to mend them. They realised, he hoped, that the earth was handed over to them to a large extent for management, that things would not be done unless they did them, and that they were agents, that the duty and responsibility rested upon them, and that the powers above depended upon them to use their intelligence, with which they had grown by the process of evolution, for the benefit and material salvation of mankind. (Applause.)

The Bishop, in proposing a vote of thanks to the chairman and Sir Oliver Lodge, offered the latter the tribute of his personal thanks for the help his writings had been to him in the work he had been called upon to do. He looked upon Sir Oliver Lodge as one of the scientific men who more than most had bridged over the gulf between faith in science and faith in religion. He was a scientific man who had spiritualised material things instead of, as some had done, materialising spiritual things. (Hear, hear.)

Sir Robert Hadfield seconded. He often wondered, he said, why we did not try a little more the American system of heating our houses from a central stove. This would be an important means of obviating some of the smoke difficulty. He was sure when Sir Oliver Lodge talked about temperatures he would give them credit in Sheffield for studying that particular branch of science. When he said that steel might be spoiled or made satisfactory by merely the difference in temperature of some five or six degrees Centigrade, it would be understood what a fine science the manufacture of steel had now reached. For the methods by which they arrived at that exactness of temperature they were greatly indebted to such men as Sir Oliver Lodge. (Hear, hear.)

Sir Oliver Lodge, in reply, remarked that as Sir Robert Hadfield had been selected to join the Royal Society, he claimed him henceforth as a colleague. Indeed, he had been known to him for a long time, by his researches in steel, as a scientific man. Congratulating Sheffield upon having obtained a University in such a short time, he observed, "We think we go quickly in Birmingham, but in Sheffield you go still more quickly."

SMOKE AND ITS POSSIBLE DESTRUCTION

—— BY ——

T. SCOTT ANDERSON, Esq., A.M.I.C.E., M.I.E.E.

It is perhaps a difficult thing to realise the enormous amount of energy which is daily wasted by reason of inefficient apparatus for the proper consumption of fuel. Some of this waste may be excusable, but there can be no question that a large amount could be and should be prevented.

I am aware that the demands on a steam boiler in steel works is, perhaps, heavier than in any other industry. The heat supplied is fluctuating. One hour the boiler is working to its utmost capacity, the next it is comparatively idle.

I am also aware that in many places the boilers receive but scant attention even from those in charge. The stoking is haphazard: on one part of the furnace the fuel is piled in lamentable thickness, at other parts nothing. For this method of firing there is no excuse, but there should be a penalty.

The question as to how we shall prevent smoke is readily answered by saying, "Obtain perfect combustion of your coal," but the modus operandi of obtaining this perfect combustion is not so easily forthcoming.

There are, roughly, two distinct causes of smoke nuisance :—

I. Factory and Furnace Smoke.

II. House Smoke.

and on both subjects a vast amount of advice has been given, but the difficulties have not yet been overcome, although the improvements in smoke prevention apparatus have been considerable and of the most satisfactory nature.

Let us first consider the factory and furnace smoke. To be a perfect apparatus a boiler should utilise the whole of the energy of combustion, but, unfortunately, there is no perfect boiler.

When bituminous coal is fed to a fire the first action which takes place is the liberation of about 30 per cent. of its weight as

volatile matter, which, although it possesses a high calorific value —is allowed to pass to the chimney unused and disappears into the atmosphere, where it plays havoc with the health of the people and disfigures everything beautiful.

This smoke is often spoken of as small particles of unconsumed coal. Such a description is hardly correct. The smoke given off is really that portion of the fuel which can readily be distilled by the temperature of the furnace, and which is essentially a tarry matter. The volatile hydrocarbons may possibly be evaporated as the smoke passes through a hot zone, and we may take it that the exact composition of the volatile matter which has been distilled is largely controlled by the temperature to which it is subjected.

The fuel fed to the furnace of the boiler cannot burn until it has reached a certain temperature, and this temperature is not reached until the whole or nearly the whole of the volatile matter has been distilled.

We therefore not only receive this large percentage of tarry matter into the atmosphere of our cities, but we also sustain a very considerable loss in deliberately allowing a great portion of the heat energy to escape without performing the service it should have performed.

But this does not represent the whole of our loss in the great majority of cases owing to the undue admission of air which rushes along the furnace and renders it still more impossible for the distilled matter to be consumed.

Sir Oliver Lodge mentioned during his address that it is impossible to bring a flame into contact with a cold surface, and that in such an attempt perfect combustion is impossible. Sir Oliver thus touched upon one of the most difficult problems in boiler firing.

The water is altogether too close to the fire, and before the heat can reach the comparatively cool surface it must force its way through a layer of unburnt and cool gas.

You will quite understand that in trying to overcome this resistance a certain amount of heat is lost, so far as useful work is concerned. The great majority of boilers have in their construction done everything they possibly could to increase the losses and to prevent economy. I do not, of course, wish to convey the impression that boiler-makers have had any such idea in their designing of boilers, but the fact remains that the

boiler as an economical apparatus leaves much to be desired.

We have therefore to seek for two remedies—

(1) Better consumption of fuel.

(2) Proper regulation of air supply.

(1) We are called upon to raise the whole of the distilled volatile matter to such a temperature as will ensure perfect combustion.

(2) We must so arrange to feed the coal that the delivery to the furnace shall be slowly made and yet adequate for the necessary heat, and as far as is possible without requiring hand fire-raking. There must be no undue admission of air to the furnace which would be highly objectionable to the ideal process of heat extraction, but of course sufficient oxygen to aid combustion. Every pound of coal requires a given quantity of oxygen for its complete combustion. Consequently a definite quantity of air, varying with different fuels.

Too little oxygen prevents complete combustion, but an excess is equally detrimental, as it involves a loss of heating energy, equal to that required to bring the excess of air to the temperature of the escaping gases.

Can these requirements be met ? So far as underfired boilers are concerned there is an appliance which has met the conditions most satisfactorily.

The feed of the coal is slow, and the gas evolved from the fresh fuel is raised to a combustion temperature as it passes over the incandescent fuel further on, thus realising the first condition of smokeless combustion. The action throughout is one of an endless chain of short interlocking gratebars, which are supported by rollers laid on side frames.

The grate has at each end a drum over which the chain passes. The coal is fed the whole width of the grate and the depth of the layer easily regulated. When the conditions require it, the air supply to a portion of the grate can be cut off during light load periods, thus maintaining the maximum of efficiency under all conditions.

The apparatus throughout seeks to achieve the continuous feed of the fuel in such small quantities as to ensure the combustion of all the volatile matter which is distilled on the coal reaching the heated surface of the furnace.

The grate is self-cleaning, requiring no firing tools.

As regards other boilers—and I understand the following

applies to every type—the most recent device goes a long way to solve the problem of smoke prevention.

Briefly described, the principle employed is the utilisation of producer gas as an auxiliary fuel to the ordinary small bituminous coal. The apparatus comprises a gas producer which delivers at the far end of the furnace and behind the coal-fire, but in front of the chimney opening, a volume of gas by means of which the distilled volatile matter is raised to a high temperature and consumed.

The smoke created by this distillation is carried by the draught until it reaches this intervening wall of intensely hot flame. There it is consumed, and so perfectly that no solid particles are allowed to pass to the atmosphere.

The tests so far have been highly satisfactory. Not only is the auxiliary heat rightly employed, but the otherwise waste matter is called upon to give up its energy. There is a large saving in the coal bill and smokeless combustion.

As it is most likely that Mr. Booth will more fully, and with much more authority, discuss this question of ideal feeding of fuel and the best methods for the prevention of smoke, I will, with your permission, pass to metallurgical furnaces.

May I again refer to the admirable address given by Sir Oliver Lodge. You will doubtless recollect the remarks he made re radiation. Sir Oliver stated we must look towards high radiation to obtain the ideal heating of cold surfaces—not depending either upon the hot gases alone—although they will add their quota—neither to a smoky flame, which only does the work in an imperfect manner, but to obtain highly radiating solid surfaces to force the heat where required. Sir Oliver Lodge also particularly referred to the question of the enormous increase in radiation as the temperature increases.

I hope these remarks from such an authority will permanently dispose of that very ancient belief that the object to be heated must of necessity be in contact with the fire or flame. When this is realised and acted upon we shall hear no more of those statements which have been too freely made—that smoky flame is essential to certain metallurgical operations.

In Germany and France these radiation furnaces are employed with complete success. The temperatures which can be obtained, adjusted and maintained are considerable, being from 1,050C. to 1,850C. or 1,922F. to 3,360F.

Gas is employed in these furnaces, being first perfectly mixed with the exact amount of air necessary for complete combustion. This mixture is then burnt as desired.

In some cases it is highly necessary that the products of combustion shall not be in actual contact with the metal being heated. In such a case the furnace is designed with a double circulation of the flame, which first rises between the heart of the furnace and a wall of dolomite briquettes and then descends, so that the briquettes are very nearly at the same temperature as the interior of the furnace. Almost any metallurgical operation can be conducted in such a furnace—the saturation of the metal is assured, and there is an entire absence of smoke and dirt.

In Remscheid the success has exceeded their anticipation, and where once huge smoky furnaces were employed, they now have the cleaner, more economical, and much more scientific method of treatment.

Another point of importance—I may add of vital importance—in metallurgy is the adjustment of temperature. Any furnace which can give an exact temperature and maintain it must be of the highest moment to the metallurgist.

On Monday, in this Hall, Sir Robt. Hadfield said, "We have studied the question of temperatures in Sheffield, and we know that the difference of 5 or 6° C. may spoil steel or make it satisfactory."

I quote Sir Robert at this point in order to emphasize the importance of accurate and scientific treatment of all matters and operations in which temperature plays a part.

When that extreme accuracy is combined with a smokeless furnace it is of the greatest value to Sheffield industries, and also from the point of view of this Association.

ELECTROLYTIC OPERATIONS.

Of recent years increasing attention has been given to electrolytic operations, and at the present moment we see on every hand great—and let us hope successful—attempts being made to get away from the old ugly smelters which belch forth smoke and poisonous fumes to the detriment of everything living, and to use a newer and better method of extraction.

A large plant has recently been erected for the treatment of copper sulphide ore. There is no smelting—simply crushing, roasting (the sulphur being used for the manufacture of H_2SO_4), leaching and electrolysis.

The copper is produced in pure sheets, and the complete cost of extraction, even on low-grade ores, is much below that of the old form of smelting.

Zinc, lead and other metals are being similarly treated by smokeless power generation.

HOUSEHOLD SMOKE.

We admit freely that assuming we can obtain a smokeless factory and furnace, we are still face to face with the greatest evil, namely, house fires. With the present open fires in full blast we cannot hope to live under the ideal conditions of a smokeless atmosphere.

The number of grates, each possessing a hidden virtue, is legion, but it seems to me that we are attempting the impossible no matter what type of grate we employ, so long as we burn a bituminous coal in an open fire. No doubt the problem could be solved, but the question is, can it be solved to allow of the solution being employed in the house worth only a few shillings per week.

Is there a remedy ? So far as it is possible to judge at this moment we can only look to one of two things :—

1. The general use of a cheap and efficient gas.
2. Coalite.

The difference between coalite and coke is considerable. Coke—as you are aware—is subjected to a high temperature, which means that the whole of the volatile matter has been removed ; but more than this, the remaining constituents have been considerably altered, rendering it difficult to light.

Coalite, on the contrary, is a coal which has been subjected to only a low temperature, just sufficient to drive off about three-fourths of the volatile matter. The balance of the volatile constituents come away when burnt, the flame being somewhat yellow, but without smoke. Coalite would solve the problem. Let us hope that soon it will be available at a reasonable price to all domestic fires.

In conclusion, there appears full evidence that smoke from factories, mills, and industries of all kinds can be stopped, not

only to the great advantage of the dwellers in the vicinity of such industries, but to the advantage and economy of the owners.

There is no question of penalising. A smokeless boiler furnace means an economical boiler furnace. It means money saved, a purer atmosphere, a healthier people, and every authority should strenuously strive by every possible means, not only to enforce their bye-laws but to take such steps as will ensure the manufacturer being fully conversant with the fact that smoke is not a necessity: that it can be stopped to their advantage, and that the public interest demands a strict observance of any reasonable legislation—more particularly as manufacturers can now obtain a solid guarantee that the apparatus employed to produce perfect combustion not only achieves that object, but further, that the cost of erection can be saved within a couple of years.

ABSTRACT SUMMARY OF LECTURES

ON THE

TRAINING & WORK OF STOKERS

DELIVERED BY

MR. W. H. BOOTH, M.AM.SOC.E.,

At the Borough Polytechnic Institute, under the auspices of the Coal Smoke Abatement Society,

On which Mr. Booth's Conference Address was based.

THERE are three different states of fuel—solid, liquid, and gas, and they are all more or less identical as regards their chemical composition and consist of carbon and hydrogen in varying proportions.

The chemistry of fuel combustion is extremely simple. It is necessary to know something of chemistry in order to understand combustion. There are some eighty elementary bodies known to chemists, but only four, or at most five, are of any significance for the engineer. These are oxygen, nitrogen, carbon, hydrogen and, in a more or less degree, sulphur. Every elementary substance has a certain weight in which it combines with certain fixed weights of other elements. The equivalent weight of the foregoing five elements—with which alone we are concerned—are as follows:—Hydrogen, 1; Carbon, 12; Nitrogen, 14; Oxygen, 16; Sulphur, 32. Put into the simplest language, these figures mean that 1lb weight of hydrogen will combine with 12lb. weight of carbon, or 24lb. or three times 12lb. or four times 12lb., and so on. That is to say, that 1lb. of hydrogen can never be found combined with 9 or 11 or 17lb. of carbon or with any other weight excepting some multiple of 12. Similarly, 1lb. of hydrogen must combine with some multiple of 16lb. of oxygen; or 12lb. of carbon must combine with 16 or with 32lb. of oxygen; and 32lb. of sulphur when burnt will combine with twice 16 of oxygen. In every case these and other elements are

always combined with the same proportion of their atomic weights. This greatly simplifies the chemistry of combustion.

So far as regards gases of a simple nature, that is to say, elementary gases such as hydrogen, oxygen and nitrogen, the above weights may be said to represent the relative weights per cubic foot of the gases; thus, 1 cubic foot of oxygen weighs sixteen times as much as 1 cubic foot of hydrogen and as much as 14 cubic feet of nitrogen. When we write down H_2O, we mean that two volumes of hydrogen have combined with one volume of oxygen, the weight of the hydrogen being two and the weight of the oxygen being sixteen; the resulting gas is steam or gaseous water and the weight of 1 cubic foot of this gas—for steam is a gas—will be 18 divided by 2, for all combined gases, from however many atoms of other gases they are built up, occupy a volume of two. Thus the gas, carbonic oxide, or CO, is built up from one atom each or carbon and oxygen, and occupies two volumes, so that its density or relative weight is $\frac{12 + 16}{2} = 14$. Again carbon dioxide, or CO_2, though built up of three atoms, still occupies two volumes, and its relative weight or density is $\frac{12 + (2 \times 16)}{2} = 22$.

We will now enquire into the properties of the four elements with which we are concerned. **Oxygen** is a gas which forms 23 parts by weight of the atmosphere we breathe and 21 parts by volume out of each 100 volumes, the remainder being nitrogen. Its atomic weight is 16 and it unites with almost all known substances, the act of combination producing great heat. Oxygen is thus necessary to combustion.

Nitrogen forms 77 parts by weight of the atmosphere and 79 by volume, the remainder being oxygen. Its atomic weight is 14 and it is not a chemically active substance; its only effect in combustion being to reduce the temperature simply because for every pound of oxygen there is roughly run into a furnace 4lb. of nitrogen which has to be heated up slowly by the heat of combustion due to the oxygen. It is therefore merely a means for diluting temperature which we cannot avoid.

Carbon is only known as a solid. In combination with hydrogen it forms many substances, such as pitch—which is solid—mineral oil, animal oil and vegetable oil—which are liquid at ordinary temperatures, and gaseous substances in which hydrogen is present in larger quantities. Thus carbon and hydrogen, either alone or in combination, form all our known fuels. They

are more or less mixed with mineral substances which produce ash and clinker, or in the case of wood and coal, with a certain amount of oxygen which is believed to exist in the proportions of water, viz., H_2O, and is therefore useless as fuel to that extent. The atomic weight of carbon is 12. It exists in three forms; the diamond is pure crystallised carbon and will burn readily in oxygen; graphite or "black lead" is another form of carbon; while the forms in which it appears as fuel are well known, as charcoal, coke, anthracite coal, and, combined with hydrogen, bituminous coal, wood, straw, etc. When carbon burns with 1 atom of oxygen it produces CO or carbonic oxide, and the amount of heat generated is 4,415 British thermal units. When carbon is burnt into CO_2 it produces 14,647 B. Th. U. The difference between these two is 10,232. If carbon could be supplied in the form of gas, the first oxidation to CO would also produce 10,232 thermal units. The difference between 10,232 and 4,415 is 5,837. This is the latent heat of vaporising carbon, as to which we shall learn more later. These two oxides of carbon are the only two which we know of in connection with combustion; and it is to be noted how important it is that the second oxide, or CO_2, should be the one made, or otherwise the amount of heat lost from each pound of carbon will be 10,232 thermal units. This may happen if insufficient air is supplied to the fire.

Hydrogen is the lightest substance known. Its atomic weight is 1; two parts by weight combined with one of oxygen go to form water; the amount of heat evolved in the combination is 62,100 B. Th. U. As in all cases of practice the gas passes off in the form of steam, the real heat available is less than this, because steam contains so much latent heat of vaporisation, and only about 52,380 Th. U. are really to be counted upon from the combustion of 1lb. of hydrogen. Seeing that the duty of a stoker is to manufacture heat, it is necessary to know something about this property. We know what we mean when we speak of heat; but it is necessary to have some means for measuring it. We must therefore have a unit of measurement just the same as a pound weight is our unit by which we measure the weights of other substances. Now the British thermal unit of heat is the amount of heat which is required to raise the temperature of 1lb. of water through 1° Fahr., or say from 39° to 40°, this being the temperature of greatest density of water at which the thermal

unit is measured. Now by temperature we mean that quality of heat by which it is enabled to pass from one body to another. We measure temperature as a rule by the expansion of the metal mercury, and we divide the expansion of this metal as measured from the freezing-point of 32° and the boiling-point of 212° into 180 divisions, each division representing what we call 1° Fahr. Now we may have a large mass of water at a temperature of, say, 50°, and we may have a small quantity of iron at a temperature, say, 100°. A pail full of water at 50° has many hundred times as much heat in it as 1oz. of iron at 100°, yet heat will pass from the iron to the water simply because the iron has a greater temperature. Temperature is thus somewhat similar to what we know as pressure. A small vessel of water, on the top of a house, of only one quart capacity, will empty itself down a pipe into a big cistern at a lower level though the big cistern may contain many thousand times the amount of water that is contained in the upper smaller vessel. The small vessel empties itself by virtue of pressure, and this is just what high temperature means in regard to heat. When we speak of latent heat we mean that heat which is necessary to maintain a body in its state of liquid or gas If a vessel containing ice be heated by a flame, a thermometer immersed in the vessel will shew 32° of temperature. Though the heat of the gas flame under the vessel is being absorbed by the ice no change of temperature occurs until the whole of the ice has melted. When the ice is all gone the temperature will begin to rise until it reaches 212°. When this temperature is reached in the open vessel no further temperature will be produced, though the water will continue to absorb the heat of the gas flame until the whole of the water has disappeared. The heat which went into the ice is called the latent heat of liquefaction and is represented by 145 B. Th. U. per pound of ice. Similarly the heat which disappeared in producing steam of 212° temperature from water of 212° temperature is the latent heat of vaporisation and amounts to 966 B. Th. U. per pound. When we speak of SPECIFIC HEAT we mean the number of thermal units which will raise the temperature of any substance 1°. Water requires more heat than any other substance to raise its temperature 1°. We therefore speak of the specific heat of water as 1. To raise the temperature of 1lb. of iron 1° requires only about one-ninth as much heat in thermal units as to raise the temperature of 1lb. of water by 1°. To raise the temperature of

many gases 1° requires about one-fourth to one-fifth of the heat which would raise the temperature of 1lb. of water 1°. Thus the specific heat of oxygen is 0.217; of nitrogen 0.244; of hydrogen 3.410; of carbonic oxide CO 0.245; of carbonic dioxide CO_2 0.216.

COMBUSTION.

Our only practical source of oxygen is the atmosphere. For each 12lb. of carbon perfectly burnt we require 32lb. of oxygen, so that the weight of oxygen required for 1lb. of carbon is 2.66 or ($2\frac{2}{3}$), the total weight of gas produced being $3\frac{2}{3}$; but for each pound of oxygen there is about 4lb. of nitrogen, so that the total amount of air is nearly $2\frac{2}{3}$ x 5 or $\frac{2\frac{2}{3} \times 100}{23} = 11{\cdot}6$lb; thus the total weight of gases which come through a furnace is $12\frac{1}{2}$lb or 12.60, more accurately. Now if we could mix our air with our fuel perfectly we could burn the fuel with just the necessary chemical equivalent of air; but in ordinary practice we must get through the operation of combustion so quickly and in such a small space that we cannot insure proper mixture of air and fuel, and it becomes necessary to allow much more than the chemical minimum weight of air. In very ordinary practice, instead of 12lb. of air per pound of coal, we must provide more like 25lb. Very good practice allows about 18lb. of air per pound of fuel, and under very best conditions it is possible, perhaps, to get down to as low a weight of air as 15lb. per pound of fuel.

We now deal with the temperatures possible in furnaces. Taking carbon by itself, we have for combustion with the minimum amount of pure oxygen 14,647 B. Th. U. produced, and $3\frac{2}{3}$lb. of CO_2 as the result.

Now the specific heat of CO_2 is 0.217, so that the temperature will be $14{,}647 \div 3\frac{2}{3} \div 0.217$ or 18,440° F.

But when air is used, so much of which is nitrogen, and the weight of final gases is about $12\frac{2}{3}$lb., the temperature is reduced, first, by the spreading of the heat over the greater weight and, secondly, by the greater specific heat of nitrogen which is 0.244, so that instead of 18,440°F., the temperature of combustion of carbon in air is only 4,988°F.

Similarly, while hydrogen gives a temperature of 12,108°F. when burned with oxygen, it only produces a temperature of 4,813°F. when burned in air. Further, since in practice a great

excess of air is used, the actual furnace temperatures do not exceed 2,500° to 3,000°.

Now, whatever the furnace temperature, that of the chimney will not fall below 300° to 400° in good practice. Obviously, then, if the chimney gases are at, say, 400°, there will be twice as much heat lost when there is about twice as much air used as is chemically necessary. Hence the importance of using as little air as possible in order first to secure the highest possible furnace temperature and the smallest waste of heat up the chimney.

In order to burn bituminous coal without smoke it is necessary to have

Conditions.—First: Air must be mixed with the hydrocarbon gas that is rapidly driven off the fresh coal by the heat of the fire on which it is thrown. Second: The mixture must be kept hot enough to fire. Third: There must be ample space in which combustion of the gas must take place before the flames are cooled by contact with the colder surfaces of the boiler.

To ensure these conditions in practice the air to burn the gas should come in through the furnace door grids and it should sweep with the gas over the length of the fire. This will mix it. The furnace must have some protection by means of a firebrick-lining so that there may be no serious loss of heat until combustion is complete. The draught must therefore be powerful enough to draw in such air through the door grids. Therefore, when necessary to check the combustion of the fuel on the grate, this must be done by ash-pit dampers, not by chimney dampers. The chimney damper stops both the air below and above the grate and causes smoke, because the draught is then insufficient to draw the necessary air through the door grids. In cases where boilers are so set that the flame rises vertically upwards from the grate and passes immediately between or over cold surfaces it is impossible to prevent smoke because there can be no mixture of air with the gases; there is no time for combustion to take place even were there any air present, and the chilling effect of the cold surfaces is so great that the hot hydrocarbon gases are decomposed and soot is inevitably formed.

The late W. Wye Williams told us 40 years ago or more everything that is to be known about smokeless combustion, with the single exception that he did not sufficiently emphasise the question of temperature.

It is from lack of temperature that all efforts involving the correct system of mixing air with the gases have proved more or less unsuccessful. Temperature alone has been wanting and temperature cannot be secured unless furnaces are sufficiently protected from the cooling effect of the boiler plates by means of a sufficiency of fire brick linings suitably arranged to secure the correct travel of the air and gas and the space for combustion; all of which Wye Williams correctly pointed out but failed to lay sufficient importance upon the essential of temperature.

When coal is thrown upon a hot fire it at once begins to give off gas. We have already referred to the question of latent heat and shown how the change of state from solid to liquid or from liquid to gaseous involves the disappearance of heat in producing and maintaining the new and higher state.

Coal, when it evaporates into gas upon a hot fire, behaves exactly the same as a piece of ice which is converted into steam. An enormous amount of heat is rendered latent and this heat all comes from the red hot fuel on the grate and chills this down to a very much lower temperature; so that a freshly-coaled fire is comparatively cool. This it is which renders so necessary the protective fire-brick which, having become heated by the fire when at its hottest, now gives forth that heat to enable the mixed air and gas properly to burn.

Since the gases from fresh coal are driven off in two and a half or three minutes after firing, the supply of air through the doors should be gradually closed until in three minutes they are shut entirely, the excess of air through the grate being then quite sufficient for any hydrocarbon gas which may come off after the three minutes.

Smoke may be best prevented by firing on the coking principle, the fresh coal being heaped near the door where it gives off its gas over a much longer period of time than when spread over the fire. When pretty well coked, the heap is pushed back over the fire. Firing on the spreading system tends to cause smoke because the gas comes off so quickly and the fire is made cold. Hence the practice of firing down one side of the fire only and then down the other side, so that half the fire surface is always bright. Or the back and front halves of the fire are covered in turn with the same object. Machine stokers are made in various forms to imitate all the methods of hand firing.

Insufficient draught is variously remedied by the aid of a steam jet to help forward the air, especially through the door grids. Or a fan may be employed to send the gases through the flues and the dampers worked as already described.

In all cases brick arches, bridges or other devices so arranged that the correct form of furnace and disposition of draught is secured are essential to combustion. The Lancashire boiler furnace with a sufficient draught is correct in every particular but that of temperature, and would be entirely right if it could be lined with a durable lining of fire-brick. But it will always aid to the comprehension of the matter to bear the form of the Lancashire furnace in mind.

One of the great difficulties connected with mechanical stokers is that in the coking variety, where the bars are of the travelling or moving description, the fuel which enters thickly at the front of the furnace becomes gradually burnt up so that the back ends of the bars are practically bare of fuel, and very large excess volumes of air are admitted which cool down the flues and choke the chimney. For many years I have drawn attention to this point and advised the use of choking plates underneath the rear end of the furnace bars in order that the supply of air could be gradually diminished to nothing at the back end. This suggestion, after many years, has now been adopted by makers of travelling bars, no doubt with great advantage on the score of economy.

It is also important that all fire-brick walls in connection with the boiler setting should be rendered air proof outside by coating them with paint or tar or other substance that will choke up the pores of the brickwork and prevent air from being drawn through. This is a point which I have advocated for 25 years, and it is only recently that it has received recognition. It is, however, a very important factor in draught and economy.

As regards smoke itself, we may say that there are two varieties. First, the unburnt green gas which is driven off when coal is heated. This is what is produced on all fires, and, when not ignited, escapes through the chimney in its crude form with all its load of tar and carbolic acid and other gaseous products. Black smoke is produced when this gas has entered into combustion and the flames are suddenly cooled by contact with cold surfaces, causing decomposition and the deposit of carbon in the form of soot.

There are various scales by which the density of smoke is estimated. In one case a long band on a sheet of paper or card-board is coloured densely black at one end and the colour gradually washed down by means of water towards the other end of the strip until no colour appears. Thus different scales of colour of smoke are obtained by dividing this band into so many divisions, each division corresponding with a certain degree of smoke density. If this diagram is placed so that it can be seen at the same time as the top of the chimney the colour of the smoke can be compared with the divisions of the band, and that division picked out which corresponds.

Ringelmann's Smoke Scales are simply squares of paper upon which are ruled, at right angles to one another, black lines a certain width and certain distance apart. No. 0 has no lines at all, being perfectly white ; No. 5 is all black ; the intermediate four scales consisting of the rulings crossing one another at right angles as above stated. The blackest has black lines 5.5 in width and white spaces 4.5 in width ; this is No. 4. No. 3 has black lines 3.7 in width and the white spaces 6.3 in width. No. 2 has black lines 2.3 in width and white spaces 7.7 in width. No. 1 has black lines 1 in width and white spaces 9 in width.

At a distance of 50 feet from the eye the rulings are not visible, but each square takes the appearance of a mass of more or less grey or black surface with which the smoke at the chimney top can be very readily compared.

W. H. BOOTH.

2, Queen Anne's Gate, S.W.
March 23, 1907.

THE WORK
OF THE HAMBURG MANUFACTURERS' SMOKE ABATEMENT SOCIETY

— BY —

JOHN B. C. KERSHAW.

The Hamburg Verein fur Feuerungsbetrieb und Ranch-Bekämpfung is a voluntary organization of manufacturers using steam-power within the boundaries of the city of Hamburg. The Society was inaugurated in October, 1902, by a few engineers and manufacturers who believed it was possible to obtain more steam and less smoke from their steam-raising plant by scientific control, and who had the courage and independence to form this voluntary Association, instead of waiting for some outside body of persons or authority to step in and show them their duty in the matter. The Society has grown each year since its formation, and commencing with 48 members owning boilers in 1903, at the date of the last annual report it numbered 258 members and had 717 steam boilers under its control.

The work of the Verein is controlled by a committee of six to nine members, elected annually from the rank and file of the Society at the general meeting. The technical and scientific supervision is undertaken by the staff of chemical engineers retained by the Society for this special work. At the date of the last report this staff consisted of a chief engineer, four assistant engineers, three instructors for firemen, and one clerk. The chief engineer attends the committee meetings, and takes part in the discussions, relating to the work of the Society.

The funds of the Society are drawn from three sources :—

1. From the annual subscriptions of its members.
2. From payment for special work and reports for its members.
3. From payments for outside work.

The Society is thus entirely self-supporting, and its success is dependent upon the value of the return it makes to its members, for their contributions and fees. It is therefore gratifying to note that the membership shows steady growth.

The objects of the Society as set forth in the rules are the attainment of the highest possible efficiency from the heating and steam-raising plant of its members, with the least possible emission of smoke. To this end, regular examination of these plants, and of the methods of working them, is undertaken by the staff of the Society, and suggestions are made for improvements when such are required. The education and control of the firemen in the proper performance of their duties are also undertaken by the three firemen instructors on the staff of the Society. Comparative tests of fuel and tests of smoke-prevention and other appliances of a similar character are also carried out by the expert staff, and the results are circulated amongst the members.

Members of the Society can demand that their boiler or heating plant shall be regularly inspected, and that its working shall be tested and reported on at least three times a year. They have also the right to consult the chief engineer regarding improvements and alterations in the design and working of their plant.

They, on their side, by their membership of the Society, are bound to allow the chief engineer and other members of his staff free access to their steam-raising plant at all times, and are bound to make the necessary provisions for conducting the tests. They are also required to carry out the suggestions made for improving the efficiency of the plant, especially as regards the abatement of smoke, and to submit to the chief engineer all plans for extension of the plant or for changes in the methods of work.

Each plant, when brought under the control of the expert staff, is tested at the earliest possible date, and a written report upon the results of the examination is submitted to the owner. Should the firing have proved inefficient, one of the firemen instructors is sent to the Works to give practical instruction to the firemen employed there, and tests of the plant are made at intervals until this fault is remedied. Defects in design are similarly dealt with.

The annual subscription to the Society for members without any boiler or heating plant is 20 marks (£1). Members having boilers or furnaces which they desire to place under the control

of the experts of the Society, pay a further 20 marks annually for each boiler or furnace.

The extra charges for tests and reports are based upon the time spent upon them and number of experts employed. Engineers are charged for at the rate of 20 marks per day, and firemen instructors at 5 marks per day. Special reports upon patented appliances are charged for at the customary rates; members receive a special discount of 30 per cent. on these, as compared with outsiders.

Having thus briefly sketched the organization and objects of this Society as these are set forth in the explanatory pamphlet issued by the committee of management, I will now give some facts and figures drawn from the Fifth Annual Report, which covers the work done for the year ending December 31st, 1907, the Report for 1908 not yet being issued to the members.

I may state that these Reports are comprehensive quarto pamphlets of 50 or more pages written, of course, in German, and they are well worth the study of any engineer or manufacturer interested in the allied subjects of Smoke abatement and fuel economy.

On January 1st, 1908, the Society had, as already stated, 258 members and 717 boilers on its register, an addition of 34 members and 91 boilers as compared with the numbers on the 1st of January, 1907.

In order to cope with the increasing amount of work, a fourth engineer was added to the staff during 1907, and on January 1st, 1908, this included one chief engineer, four assistant engineers, and three instructor stokers. The duty of these latter is to train stokers for their work either at the central experimental boiler installation of the Society or at the member's works. The reduction in smoke emission from the member's works and improvement in fuel economy since the Society was started in 1902 is largely attributed to the very large number of stokers who have benefited by the special training, thus emphasizing the teaching of Mr. Booth's paper on this subject.

The report of the chief engineer states that during 1907 27 first examinations of plant and 98 prolonged steam-raising efficiency trials were carried through.

In connection with these first investigations of plant, 93 stokers received instruction at the hands of the Society's instruc-

tors on 140 days. The revision tests of steam-raising efficiency, in order to see whether the improvement due to the Society's overhaul of the plant and instruction in stoking was being maintained, numbered 418. It is this revision work of the Society which is by far the most important, for without these repeated and constant visits of the Society's officers, the stokers would soon relapse into their original faults as regards methods of stoking.

The methods for preventing smoke, suggested by the engineers, were being more generally adopted. In the majority of cases the addition of an apparatus for regulating the admission of secondary air, automatic in its action, was found sufficient. This apparatus is simple to construct, does not in any way limit the choice of the user as regards fuel, and is not costly. The engineers of the Society have been able to suggest alterations in the design, which have lessened the cost of maintenance of the apparatus. Mechanical stoking apparatus has not been extensively adopted by the Society's members. The reason for this lies partly in the fact that unscreened English and Scotch coal is obtainable in Hamburg at very low prices, and that this coal gives very good results with simple hand-firing. Nevertheless, the officials of the Society believe in the advantage of mechanical firing for large steam-raising installations, and numerous trials have been carried out during recent years, bearing upon the working and maintenance of particular classes of mechanical stoking apparatus.

No exact information could be given in the 1907 Report concerning the improvement in the atmosphere of Hamburg due to the efforts of the Society. It was hoped, however, that in the next Report some scientific data would be published upon this very important point, since the Rübner apparatus, for estimating the amount of solid matter and soot in the air, had been installed during 1907 at five different places in the city, and a record of the results obtained was being kept by the engineers of the Society. This method of soot estimation depends upon the collection of the soot, etc., upon a filter, and the determination of the amount by a colorimetric method. It would certainly be useful to have the apparatus installed in Sheffield and other large English cities, since the records would help to remove some of the ambiguity relating to the subject of smoke-laden atmospheres.

Owing to the high price of fuel during 1907, the Society's aid in the valuation of fuels was much in demand. The attempts

to introduce more scientific methods into the sale and purchase of fuel meets with their strong support, and the progress made in this direction during 1907 was noteworthy and encouraging.

The engineers of the Society had been engaged lately upon an investigation relating to *marine boilers*, but the results of this investigation were not ready for publication in the last Report.

The detailed results of some of the steam-raising tests given in Section B. of the chief engineer's report show once again the importance of training firemen for their work, and also the necessity for constant control of the conditions as regards draught and temperature in order to obtain the best results.

As a typical example of the results achieved the following case is given in the 1907 Report :—

> The two boilers were of the Lancashire type, were quite enclosed by brickwork, and were provided with automatic apparatus for regulating the supply of secondary air behind the bridge. The fuel used was Westphalian unscreened coal from the Hugo mine. The trials lasted each eight hours, during which period from 2,500 to 3,200 kgs. coal were consumed, equal to from 54.5 to 69.7 kgs. per hour per square metre of grate area. The first test was made with the usual stoker, working under his normal conditions. The working efficiency of the boiler was only 58 per cent.—28 per cent. of the total heat value of the fuel being carried away by the exit gases. One of the Society's instructor stokers was then given charge of the two boilers during the second eight-hour trial, and the efficiency rose to 72 per cent., while the heat losses in the exit gases were reduced by one-half. The third trial was made with the ordinary stoker, after some instruction had been given to him as regards the best methods of firing, etc. The efficiency in this case was 67.7 per cent., or nearly 10 per cent. better than the first test, although not so good as the efficiency attained in test No. 2. The drop of 5 per cent. was partly accounted for by the fact that the rate of combustion was higher, and the exit gases were passing to the chimney at 275°C. (527°F.), as compared with 250°C. (482°F.) in the earlier test.
>
> Other tests, of which full details are given in the 1907 Report, show gains of 7.4 per cent, 8.9 per cent., 15 per cent., 5.6 per cent., 6.6 per cent., and 12.9 per cent. respectively, due to the substitution of trained for untrained men.

Section C. of the Report deals with the smoke-abatement tests made with a German type of mechanical stoking apparatus, and Section D. with the advantages of using a water-circulating device within the boilers. In Section E. the method and apparatus used by the Society for obtaining average samples and tests of the exit gases are referred to, and a scheme for giving firemen a bonus upon the results of the CO_2 tests, is described. The system is based upon offering the stokers 5 per cent. of the savings effected in fuel-costs, for all percentages of CO_2 above 8 per cent, but a deduction is made should the presence of carbonic oxide or of unburned hydrocarbon gases be detected in the exit gases. The apparatus for taking average samples is reported to have been very generally adopted by the Society's members. Section F. deals with fuel-testing, and contains the results of a very large number of analyses and determinations of the heat value of the samples of coal sent for examination by members of the Association. A list of members completes this most valuable Report.

In conclusion, may I be allowed to say a few words upon the lessons which we in this country may learn from the example of Hamburg. There is a general concensus of opinion among those who have studied this question of smoke-abatement that in most cases the emission of smoke from coal-fired furnaces and boilers can be greatly reduced, if not entirely suppressed. The agencies required are two, namely, (1) the proper supervision of the furnaces and boilers by chemical-engineers who have made a special study of the practical side of fuel combustion, and (2) the employment of properly-trained stokers for firing the heating appliances. In large works the expert oversight can be obtained by the setting apart of an engineer or chemist for this special duty: in small works operating only one or two furnaces and boilers this oversight is more difficult to obtain, while in neither case is the provision of properly-trained stokers adequate.

The Hamburg Verein fur Feuerungsbetrieb und Rauch-Bekämpfung furnishes a notable example of what can be achieved by the smaller manufacturers themselves, when they combine together and deal with this problem of smoke-abatement on scientific lines.

In these modern days when the initiative to action on all questions relating to the health and welfare of the community is supposed to come from the State or the Municipality, it is refreshing to turn to the record of the work of the Hamburg

Manufacturers' Smoke-Abatement Society, and I am not without hope that before long we shall be able to point to an equally useful and flourishing Society in one of the large manufacturing towns of this country.

The conditions prevailing here in Sheffield differ, no doubt, in many respects from those obtaining elsewhere, and the greater portion of the smoke emitted from the chimneys of your city is no doubt due to the special requirements of the steel-melting and annealing processes. But, I have little reason to doubt, that the supervision which might be given to these furnaces by the members of an expert staff of a Society run on the lines of the Hamburg Society, and by the employment only of stokers who had received special training for their work, would result in a great improvement in the cleanliness of the atmosphere of the town, which is stated to hold the sunshine record for the north of England.

SMOKE ABATEMENT.

The Powers and Duties of Local Authorities in securing the Abatement of Smoke Nuisance. Difficulty of obtaining Conviction leads to reluctance to Prosecute. The obligation of the Central Authority. Great saving to be effected by Smoke Abatement Devices. Some suggested Amendments of the Law.

By LAWRENCE W. CHUBB, F.C.I.S.,

Secretary, Coal Smoke Abatement Society, 25, Victoria St., London, S.W.

THERE are few matters coming within the purview of sanitary authorities which give rise to more anxious consideration or greater dissension than the subject of smoke abatement.

In some towns, it is true, the problem is resolutely faced, and where this is done, notwithstanding many difficulties, the black smoke nuisance has been greatly minimised, if not suppressed. In other places nothing whatever is attempted, various excuses being made for inaction.

For instance, it is often asserted that the law cannot be put into motion against offenders without persecuting the best friends of the town; or that black smoke is a token of prosperity; or that it exercises no prejudicial influence on public health. It is true that in other places, where a vigorous effort has been made to secure the observance of the law, the difficulty of securing convictions is so great, or the penalties inflicted so trivial, that the local authority has given up the struggle in despair.

The records of the Coal Smoke Abatement Society demonstrate that, although there are many difficulties in the way of enforcing the law, and although the law needs drastic amendment in some respects, still the existing powers of local authorities ought to be more widely appreciated and exercised than has hitherto been the case.

The Public Health Act, 1875, contains provisions on the subject which apply to the country at large, with the exception of the Metropolis, and a few provincial cities and towns like Birmingham, Coatbridge, Edinburgh, Glasgow, Leeds, Leicester, Liverpool, Nottingham, and Oldham, which are governed by special provisions in local Acts for the abatement of smoke.

Sec. 91, sub-sec. 7 of the Public Health Act, 1875, enacts that "any fireplace or furnace which does not, as far as practicable, consume the smoke arising from the combustible used therein, and which is used for working engines by steam, or in any mill, factory, dye-house, brewery, bake-house, or gas work, or in any manufacturing or trade process whatever"; and Sub-sec. 8 that "any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance, shall be deemed to be a nuisance liable to be dealt with summarily in manner provided by this Act."

Prosecutions for smoke nuisances are generally instituted under Sub-sec. 8, which raises the simple issue whether black smoke has been emitted in such quantities as to be a nuisance, and does away with a valid defence to a charge under Sub-sec. 7, that the fire-place or furnace "as far as practicable" consumed the smoke. A charge under Sub-sec. 8 does not enable the defendant to call evidence as to the construction of the furnace, or as to the quality of the fuel used, or to show that the fire-place or furnace has been carefully attended to.

It should also be remembered that it has been held that "where black smoke issued from a chimney several times a day during a series of days for periods varying from a few minutes to upwards of an hour, the magistrate was justified in finding that the smoke issued in such quantity as to be a nuisance, although there was no evidence that any particular person, or property, was injuriously affected thereby" ("South London Electric Supply Corporation v. Perrin," 1901, 2 K.B., 186). The issue of "black smoke" from any chimney not being the chimney of a dwelling-house is, therefore, *per se*, a nuisance, and need not be proved to be injurious to health in order to be a nuisance ("Gaskell v. Bayley," 38 J.P., 293).

Black smoke being a nuisance, Sec. 92 of the Public Health Act, 1875, imposes upon the local authority the duty of abating it and of putting into execution any Act applying to its district

requiring fire-places and furnaces to consume their own smoke. If it does not do so, it may be treated by the Local Government Board as in default.

In this connection it is greatly to be regretted that the Department of State entrusted with the duty of compelling local authorities to enforce the provisions of the Public Health Act has hitherto set the example of disobedience in persistently refusing to exercise the powers which Parliament has placed in its hands, and it is unfortunately the case that, where the local authority deliberately chooses to defy the law and neglect its duty, it has hitherto been able to do so with impunity. It may be that the hands of the Local Government Board are already over full. However that may be, it has been singularly unwilling to secure the observance of the law in the matter of smoke nuisances. If the Department were to intervene in the case of a few notorious delinquents and charge upon them the cost of enforcing the law, less would be heard in the future of the inertia and indifference displayed by those authorities in the performance of their statutory obligations. The excuse of other councils who decline to put the law in motion on the ground that their neighbours take no action, would also disappear.

Now, although as baldly stated, the law with regard to smoke nuisances appears adequate, experience has proved that many difficulties of a practical nature arise in carrying it out.

In the first place, many local authorities have complained to the Coal Smoke Abatement Society of the difficulty of securing convictions in cases where there is no stipendiary magistrate. I desire to cast no slur upon the probity of the general body of magistrates; but it is pointed out that in many cases the proceedings in connection with smoke prosecutions are heard by a bench of magistrates who will probably be found to comprise manufacturers not immune from similar offences themselves, or at least friends of the defendants, or persons who labour under the delusion that black smoke cannot be avoided. Their natural bias, if they have one, must therefore be against what they regard as an interference with trade. In such cases convictions are often either impossible to obtain or are accompanied by such paltry and wholly inadequate fines that the offender prefers to offend again rather than take steps to abate the nuisance. The object of the prosecution, consequently, fails, since the punishment, if any, does not act as a deterrent.

I am confident that I shall be voicing the opinion of every authority anxious to prevent black smoke nuisances when I say that the fines inflicted should be far higher than has hitherto been the case, and that they should be doubled or at least materially increased for each recurring offence. Manufacturers would speedily find means for preventing the issue of black smoke if they found it cheaper to do so than to go on fouling the air and trying their neighbours' tempers by a want of consideration for the common weal.

Then it must not be forgotten that the sanitary inspector is placed in a very unsatisfactory position when, as is often the case, the offenders within the area under his observation include members of the authority by which he is employed. At the least he runs the risk of offending those on whom his advancement depends, or earns a reputation for excessive zeal if he ventures to urge that proceedings should be taken in such cases. Conse quently, and until the sanitary inspector has been placed in such a position that he cannot be dismissed from his office without the concurrence of the Local Government Board, he will require considerable courage and fortitude to press, it may be, members of his own public health committee to abate nuisances.

In other cases inactivity is evidently due to a fundamental misconception of the subject. The excuse given to the Coal Smoke Abatement Society on behalf of a Midland town may be cited as a typical illustration of this assumption. It was said on the local authority's behalf that the " Council will not take any steps in the matter, as they are too glad to have the smoke as an evidence of renewed trade ! " If every sanitary authority could be brought to recognise that the emission of black smoke is ocular proof of an avoidable waste of fuel, which, as has been abundantly demonstrated, can be remedied, to the pecuniary advantage of the manufacturer, as well as to the comfort of the public, they might, perhaps, realise the desirability of performing their statutory duties in the matter, conscious that by so doing they were acting, in disguise, perhaps, as the best friends of the manufacturer.

The Coal Smoke Abatement Society recently addressed to a number of Metropolitan firms, in respect of whose chimneys no smoke nuisances had been observed for six months, a communication asking for information upon the methods adopted in pre-

venting the emission of black smoke. Most of these firms had been on several occasions the subject of complaint from the Society, and in a number of instances of prosecution by the local authorities, when, as a result of the Society's reports, fines were imposed and abatement orders obtained. Forty-two firms responded to the request for information, many of them tendering their thanks to the Society for its action, which met with resentment in the first place, but was now appreciated, as it led to the adoption of mechanical appliances or other means of preventing the emission of black smoke, and resulted in great economy.

It has, moreover, been publicly stated that Messrs. Crosfield and Co., of Warrington, annually save £25,000 on their coal bill alone, or 1,000 tons of coal per week, by reason of the steps which they have taken to secure perfect combustion of the fuel consumed without the emission of black smoke. The chairman of a large firm in London recently assured me that his company were now saving £3,500 per annum by the use of a simple mechanical device. Other cases of a similar nature could be quoted to any extent, but I hope I have said sufficient on this aspect of the question to show that the cry that smoke nuisances cannot be put down without persecution, or without serious interference with the economical working of industrial concerns, is not one which should weigh unduly with local authorities.

Although, as I have pointed out, the issue of any black smoke is illegal, it would be unreasonable to expect that, when furnaces are first lighted, or re-charged, no smoke at all should be emitted. But there should be a period fixing an hourly limit during which smoke may be emitted, and many authorities have adopted some such rule. It seems important that a common standard should be agreed upon, for the present disconnected manner in which this matter is dealt with gives rise to glaring anomalies. Thus, at Leeds the emission of black smoke for an aggregate period of three minutes in an hour is held to be sufficient to justify action, while at Middlesbrough, until recently at all events, the period was fifteen minutes. While the fixing of a time limit by law might from some points of view be unwise, it must be borne in mind that it would be far less difficult to obtain a conviction were a fixed time limit imposed than is the case at present, when magistrates have their own views as to what constitutes a smoke nuisance.

I venture to think, too, that there is room for an alteration of the law in regard to the present complicated procedure, which gives rise to great and vexatious delays, involving the issue of statutory notices. This would be obviated if power were given to the medical officer of health to summon forthwith on the detection of a nuisance. It is also important that Government works and property belonging to the Crown should be brought within the scope of action by the local authority; at the present time such works and property are immune, and can belch forth an unlimited amount of black smoke without the possibility of restriction by the sanitary authority.

But the principal difficulty which local authorities have to face in administering the law is connected with the proof of the colour of the smoke. It is true that the issue of "black smoke" is, *per se*, a nuisance, but differences of opinion exist as to what constitutes "black" smoke. Generally, the inspector forms his own opinion from observation. In other cases he compares the colour of the smoke with the Ringlemann or Bryan Donkin smoke scale, or with the chart of smoke intensities issued by the Coal Smoke Abatement Society. He cannot scientifically prove the colour of the smoke, but can only state, that in his judgment, it should be called black.

Where rebutting, and perhaps the technical evidence of expert engineers is called to disprove the opinion of the inspector, the difficulty of securing a conviction is greatly enhanced, although the smoke undoubtedly created a nuisance and, from the popular standpoint, was black. In short, "black" is a relative term. And what one person would consider "black," another would deem "grey," especially if he viewed it from a different position. The Coal Smoke Abatement Society has therefore come to the conclusion that a vigorous effort should be made to secure the amendment of the Public Health Act, 1875, by the deletion of the word "black." All that will then be necessary to secure a conviction will be to show that smoke is emitted in such quantity as to be a nuisance, which, after all, is what the present law aims at doing. In this connection it is satisfactory to know that the London County Council, to whose zeal in the work of smoke abatement the Metropolis owes so much, evidently agrees that such an alteration of the law is an imperative necessity for the area under its control.

To sum up, the experience of the Coal Smoke Abatement Society shows that while the black smoke evil is very generally felt and deplored, many local authorities have taken no action in the matter, and that while this inactivity may sometimes be traced to apathy, or a failure to appreciate what is due to the public in the matter, it is more often due to a feeling of hopelessness in view of the uncertainty of obtaining convictions. In such cases zeal cannot be looked for until the law is simplified and extended, and a more summary method of procedure provided. Is it, therefore, too much to hope that Parliament may give its attention to this important subject, and clothe local authorities, in the immediate future, with the further powers they need for protecting the purity of the atmosphere ?

THE ELIMINATION OF SMOKE

BY THE

DISTRIBUTION OF ELECTRICAL ENERGY

By Mr. S. E. FEDDEN.

When I was asked to submit a paper at one of the Conferences of this Exhibition, I do not think I quite realised what a body of eminent non-smokers would be present, or I might have hesitated to accept the offer. I am afraid that I can hardly describe myself or my work as being entirely in the direction of smoke prevention; in fact, cases have not been unknown when I have been threatened with all sorts of penalties for polluting the usually pellucid air of our city. However, I do feel that the universal supply of electricity is doing as much as anything else at the present day to reduce the amount of fuel-smoke made in this and most other civilised countries, and on these lines, if you will permit me, I will make a few remarks which I hope will justify my statements and at the same time interest you.

As you are all aware, the business of electricity supply started some twenty years ago in real earnest for the production of artificial light, has developed tremendously within the last decade in the direction of supplying energy for use wherever mechanical power is required.

This development of the supply of power in the form of electric energy from central stations is probably one of the most remarkable engineering developments which the present generation has seen. The growth of the use of electric motor and the vast changes which have taken place in the methods of producing electricity in bulk have together brought about, in a comparatively few years, a condition of things which was hardly foreseen by the most sanguine engineers in the early days, when the provision of artificial light appeared to be the one and only practical outlet for their electricity supply.

Sheffield represents probably one of the finest fields for the electric motor which can be imagined. The aggregate total of the horse-power produced from coal burned in the workshops and factories in this city must be enormous. I regret to say I have not the figure, although some time ago I tried to get a rough idea of its extent.

The Electric Supply Department in Sheffield ranks fourth in the kingdom with regard to the magnitude of its power load at the present time, although I think it probable that nowhere is there a finer field for increase. On the other hand, here we have to compete with very cheap gas, a certain amount of water power, and an uncertain, but by no means small, amount of conservatism amongst the manufacturers. This latter, I am pleased to say, is rapidly giving way.

The rate of progress of the power supply of my department during the last eight years has been as follows :—

Year.	H.P. of Motors.	Year.	H.P. of Motors.
1902 ...	... 527	1906 ...	... 4,807
1903 ...	... 1,104	1907 ...	... 7,004
1904 ...	... 2,210	1908 ...	... 9,674
1905 ...	... 3,617	1909 ...	... 12,000

and it is worthy of note that last year was the first time the amount of energy sold for power exceeded the respective values for light and heat.

Of the grand total of about 12,000 h.p. of motors at present connected to the mains, I can assure you that the first 1,000 or so were obtained as a result of most strenuous labour in the direction of educating possible consumers to the advantages of electric power. Now it is very much more easy to obtain orders for electrical machinery, and in the East end where engineers abound, the difficulties have become comparatively small, and it has been of great interest to me to notice that during the past year or so the number of times that men of importance in this city and eminent in manufacturing and engineering businesses, have given unsolicited testimony in their public speeches to the great improvements and direct economy which they have obtained by using the Corporation supply for driving their machines.

I mentioned just now that the total horse-power of motors connected amounted to about 12,000. These provide us with a steady load during the day of about 4,000 h.p. Now in our new turbine-driven station at Neepsend the average consumption of

coal per h.p. is under 2lb., a local slack being employed in water-tube boilers. Allowing for losses in generation, transmission, etc., this is equivalent to saying that for every h.p. hour delivered into a consumer's factory at average distances from the generating station, we at Neepsend burn about 2½ to 3lb. of coal. Now, gentlemen, few people are better aware than yourselves how very much below the best is the average in the combustion performance of the ordinary power plants. In the East end we have engineering firms who possibly know as much about burning coal under steam boilers as is known, but they are by no means in the majority. I have little hesitation in saying that our h.p. hour delivered at the consumer's works at 2½ to 3lb. of coal displaces in the average factory the h.p. hour provided by the consumption of 10lb. of coal. I trust engineers will not be offended at my apparently high estimate, as I am of course quite aware that many works are running under much more economical conditions, but, on the other hand, others are even more inefficient, so that my estimate is quite a fair average. The reason of this large consumption of coal per h.p. hour is because of the number of small boilers and engines working, the irregular hours during which they work, losses through radiation owing to long lengths of steam piping compared with the very small loss on electric cables, and the inefficient and involved drives which are to such a great extent eliminated by the proper use of electric motors for driving machinery. Here, then, you will see that in the current year when the output is about 10,000,000 units, 6,000,000 of which will be for power purposes (a unit of electricity for one hour being equivalent to 1⅓ h.p. hours), we are burning at Neepsend situated some distance from the city (where most of our power units are generated), 15,000 tons of coal under modern boilers with every mechanical appliance which has yet been devised to procure perfect combustion, maintained and attended by men trained to the work and never employed upon anything else. Of course, we do make smoke at times. In cases of sudden darkness, or large demands coming on without warning, the load on the generating machinery may increase by 50 or 100 per cent. within a few minutes, and in these circumstances it is absolutely necessary to force the boiler fires in order to maintain the steam pressure.

In so far as our supply has replaced steam engines to a very large extent, this 15,000 tons of coal is replacing another 60,000

tons, at a moderate estimate, which would have been burnt in the several boilers of the various works taking the supply, so that there is a direct saving in the consumption of coal in the first instance, and, secondly, it is burnt under conditions which, as far as possible, make for smokelessness, and in a place where smoke is of small importance, instead of being allowed to belch forth at a number of points and in many cases from short chimney stacks over the town and amongst the dwellings of that portion of our community upon whose health and well-being the success and prosperity of the city is so largely dependent. As supporting my argument as regard to the actual saving of coal, I should like to read an extract from "Engineering" of a paper read by Mr. Gridley :—

"The savings possible by the concentration of electric power production in large central generating stations are of real importance, in the matter of coal and water especially.

"In a paper read by Mr. Charles H. Merz before the Iron and Steel Institute during their recent visit to Middlesborough, he pointed out that if all the colliery owners in this district purchased their power from an outside source, 1,750,000 tons per annum, worth, say £500,000, would be freed for sale.

"Not long ago the decreased consumption of coal in many of the works of this neighbourhood was brought home to the author. The local power-supply company considered they were being charged excessive freights on the carriage of coal from the mines to the power-stations. The matter was taken up with the North Eastern Railway Company, who asked to be supplied with a list of the power-consumers. Although the object of the application was obvious, the list was sent, and at a subsequent interview at York, it was pointed out by the Railway Company's representatives that whilst in every case the coal delivered at the several works during the previous years had been considerable, it had fallen to little, and in many cases nothing at all, since the introduction of a public supply of electricity. Moreover, the coal consumed at the power company's stations was far less than the previous aggregate consumption of the list of works supplied."

You, who are interested in getting rid of smoke and vapour from the air, are probably familiar with the classic experiments of Sir Oliver Lodge, who, some years ago demonstrated that smoke and soot could be dissipated by passing discharges of high

tension electricity through the air, the action apparently being that the minute particles constituting the smoke become electrified and repelled one another, and finally reached the earth in their desire to get rid of their electricity. The experiments, we are told, were very effective, and recently there was some talk of trying them on a practical scale during some dense fogs, and I understand that an experimental installation may be put down in London next autumn. Whether citizens would quite relish the idea of having their time-honoured fogs dispersed by lightning-like flashes, I do not know, but the matter is one of considerable interest, although I personally look forward to the day when, by the universal use of electric power, there shall be no more smoky fogs to be dissipated.

I am aware that you look upon domestic fires as one of the most fruitful sources of soot and fog, and I have no doubt that you are right. Immense improvements, however, are being made in this direction. It is a field which the gas companies are making, I believe, peculiarly their own, although I am very glad to say there is a large increase in the use of electricity for room-warming. The many well-known advantages which attach to electric lighting apply with no less force to the use of electric stoves. At the present time we have 600 in this city connected to the mains, the development in this direction being, I believe, due to the forward policy of the Electric Light Committee in reducing the charge for energy used for heating and cooking to 1d. per unit.

It has often been a matter of surprise to me that in England the Continental form of slow combustion stove, such as on Mr. Wright's stall, has not been received with greater favour. There is no doubt that the average English house might be made very much more comfortable than it is during our eight-months winter by some economical and easily-worked system of warming up the house as a whole. Closed stoves burning hard fuel such as Anthracite, or massive fire-brick stoves consuming a small quantity of wood and retaining their heat for a very long time, as are employed in Scandinavia, seem to me the most suitable for the moment, although I believe that this field may be successfully taken over by electricity in days to come by the development of some scheme wherein electrical energy is taken more or less continuously from the supply mains night and day, at a very low rate per unit, such as can be charged for a load of that kind,

and used in conjunction with a water thermal storage arrangement.

The electric light—the advantages of which are so well known—is now brought within the reach of everyone by means of the new metallic filament lamps, which are so economical in the consumption of electricity. Although very indirectly bearing upon the smoke prevention policy, there can be no doubt that universal electric lighting would make for a purer air or, shall I say, certainly raise the average of purity of the atmosphere within dwellings and other buildings.

However perfect the oil or gas lamp, the fact remains that every light is a little fire, one in which perhaps the combustion has been brought to a very high degree of perfection, but nevertheless a source of heat where heat is not required—a contaminator of the atmosphere, a user of oyxgen, and a point from which emanate gases which are distinctly injurious both to ourselves and our belongings.

THE USE FOR ELECTRICITY FOR HEATING ON A LARGE SCALE.

Possibly the worst offenders in the matter of smoke are the heating furnaces, and I understand that at the present time they are able to claim certain exemptions because a smokeless fire cannot be arranged in some of these furnaces without prejudice to the material being treated. Here it appears there is a great field for inventors who understand this subject. Let them hasten, or they will be too late, for the use of electricity for heating and melting metals has already developed quite beyond the experimental stage, and is much in use on the Continent, U.S.A., and Canada, though it makes slow progress in Great Britain.

I have endeavoured in the short time allowed to point out to you one of the principal ways of aiding the Society of which you are all such enthusiastic workers, namely, by the more universal use of electrical energy taken from a public supply or power company.

RECORDS OF SUNSHINE

AS GIVEN IN PAPER READ BY

E. HOWARTH, Esq., F.R.A.S., F.R.Met.S.

Curator of the Corporation Museum, Weston Park, Sheffield.

As the amount of bright sunshine received varies considerably in different years, it is necessary to take the average to arrive at any basis of comparison. It is only within recent years that general records have been kept, so to ascertain the distribution in different parts of the country, the last four years—from 1905 to 1908 inclusive—may be taken, and the towns may be divided into Seaside, Residential, and Manufacturing.

ANNUAL AVERAGE OF BRIGHT SUNSHINE FOR FOUR YEARS 1905–8.

Seaside Places.

	Hours.	Percentage of possible duration.
Whitby	1,499	37
Scarborough	1,480	37
Skegness	1,748	44
Lowestoft	1,810	45
Llandudno	1,626	41
Douglas	1,620	40
Blackpool	1,648	41
Torquay	1,834	46
Hastings	1,857	46
Bournemouth	1,877	47
Jersey	1,894	47

Residential Towns.

	Hours.		Percentage of possible duration.
Edinburgh	1,242	....	31
Worksop	1,292	....	32
York	1,326	....	33
Harrogate	1,457	....	36
Oxford	1,563	....	39
Cambridge	1,603	....	40

Manufacturing Towns.

	Hours.		Percentage of possible duration.
Manchester	1,011	....	25
Bradford	1,067	....	27
Glasgow	1,109	....	28
Birmingham	1,167	....	29
Leeds	1,185	....	30
London	1,330	....	33
Dublin	1,337	....	33
Nottingham	1,350	....	34
Durham	1,360	....	34
Sheffield	1,395	....	35

In Sheffield there are three sunshine recorders, placed in different parts of the city, to ascertain as closely as possible what effect the smoke has in blocking out sunshine. One recorder is at Attercliffe, in the midst of the large works in the valley of the Don, 150 feet above sea level. Another is at High Hazels, Darnall, still in the east end of the city, about a mile from Attercliffe, and 300 feet above sea level. The third is at Weston Park, to the west, less than a mile from the Parish Church, and 450 feet above sea level. All these recorders have been in use for seven years or more, and the following table gives the annual average :—

ANNUAL AVERAGE OF SUNSHINE, 1902–1908 (inclusive).

	Hours.		Percentage of possible duration.
Attercliffe	1,025	....	26
High Hazels	1,295	....	32
Weston Park	1,333	....	33

THE CALORIMETRIC CONTROL

OF THE

SUPPLY AND CONSUMPTION OF FUEL

By R. LESSING, Ph.D., F.C.S.

In reviewing the admirable work carried out under the auspices of the various smoke abatement organizations which has found a crowning effect in this Exhibition, it is satisfactory to note how successful they have been of late years in fighting this great evil of smoke production, though strenuously opposed in their endeavours by prejudice and ignorance.

Unfortunately the manufacturer and generally the consumer of coal looks upon the production of smoke as a welcome sign of industrial prosperity, and far from recognising the existence of a "smoke nuisance," he regards the smoke abatement societies and their executive as a "nuisance" on account of the prosecutions he has to fear on their part, adding to his worries already numerous, in this highly competitive age.

With your permission I shall now endeavour to lay a few facts before you which I hope will convince you that there is at least a possibility of bridging over the gulf separating the two opposing factors—the negligent coal consumer and the exponent of the right of a pure atmosphere.

This will be done as soon as it is brought home to the manufacturer that it would be in his own financial interests to prevent black smoke issuing from his chimney stack.

This argument is, of course, not novel; it has been freely employed by those engaged in fighting the evil. The argument was substantiated by figures, and the tons of carbon emitted from the fireplaces in home or factory in the form of black smoke have been frequently computed, in this and other

countries with more or less accuracy, and presented, expressed in money value, striking figures of useless expenditure and reduction of national wealth.

It is an argument which, on the face of it, appeals to many, and, it must be said, won over many offenders into the other camp.

The fact that a good deal of valuable carbon, lost as smoke, can be saved is correct, as far as it goes, but in attempting to effect this saving there is a great danger of encountering an economic loss in the opposite direction.

To make this clear I shall have to explain a little more closely these scientific principles of combustion.

The integral and heat-giving constituent of coal, as you are aware, is carbon, with varying amounts of chemically-combined hydrogen in the form of volatile hydrocarbons. Anthracite and coke contain little or no hydrocarbons, but these are very prominent in bituminous coals. Other and less desirable constituents are moisture, ash, sulphur, and nitrogen.

By combustion is understood the chemical combination of the carbon and hydrogen of the fuel with the oxygen present in the air. This reaction, which in its simplest form may be chemically expressed by the equations :—

$$\underset{\text{Carbon}}{C} + \underset{\text{Oxygen}}{O_2} = \underset{\text{Carbon Dioxide}}{CO_2}$$

$$\underset{\text{Hydrogen}}{H_2} + \underset{\text{Oxygen}}{O} = \underset{\text{Water Vapour}}{H_2O}$$

is of an exothermic or heat-producing nature, and is probably the chemical reaction which, in point of wide application, can claim the record on our globe.

The products of combustion are carbon dioxide (commonly called carbonic acid) and water vapour. There is, according to the chemical laws of combination, a definite amount of oxygen required to effect the complete combustion of a certain quantity of carbon or hydrogen. If too little is used, some of the carbon and hydrogen will escape combustion : if too much is used an excess of oxygen remains.

The former case represents, broadly speaking, that of smoke production. Some carbon particles or hydrocarbon vapours do not find sufficient oxygen to combine with, or else, through faulty furnace construction or careless stoking, do not come in contact

with it, if present, and consequently are emitted with the regular gaseous products of combustion from the chimney stack.

Now, one method that suggests itself to the student of the problem is to burn the fuel with a considerable excess of air. By this means, of course, especially if this excess of air is introduced into the furnace at the right place and time, the emission of smoke can be almost completely avoided.

However, the excess of air required to attain this result cannot, for economical reasons, be fully employed if thermal efficiency shall be obtained. For this reason, for every part of oxygen our atmosphere contains four parts of nitrogen, an indifferent and inert gas which does not help combustion, but escapes, unaltered, along with the gaseous products. These products of combustion give up only part of their heat to the surface to be heated, say to the boiler, and escape at a temperature considerably above that of the atmosphere through the flues and chimney. Therefore, not only does the nitrogen do no work but, being heated to that elevated temperature, it carries a good deal of latent or sensible heat away with it. The same holds good for any oxygen present in excess.

Care should therefore be taken to restrict the excess of air to the lowest possible amount compatible with complete burning of the fuel, for every part over and above this quantity will be warmed up to the temperature of the exit gases and remove a proportionate amount of heat from its proper place of activity, and therefore reduce the efficiency of the furnace. This sensible heat carried away with an undue excess of air may represent a very considerable amount of the total heat generated, and may soon equal and surpass the heating value of the carbon lost with the black clouds when working in the opposite direction with an insufficient air supply and consequent emission of smoke.

The manufacturer, whom we may here take for simplicity's sake as representing all fuel consumers, finds himself in the dilemma of being liable to err in either direction. He will pay no heed to the economic arguments of the smoke fighter, for he is afraid of losing more on one side than he gains on the other.

He will not save all that splendid volatile coal to find that his coal bill has rather increased than decreased by this process.

This, gentlemen, is, I think, the point where reforms should set in. It is all very well to employ compulsory methods and to

enforce the law wherever offence is offered. But the system of prosecutions will always be regarded as persecution by those concerned, and in the state of mind brought about by compulsion, a highly-developed instinct of passive resistance is the natural consequence.

I personally believe that methods of peaceful persuasion would serve in good stead where all that is required is to educate the offender up to a higher standard of industrial efficiency and show him the golden path that, keeping in respectful distance from the two extremes, will eventually lead to success. He would thus add to the comfort of his fellow citizens and, incidentally, benefit his own pocket.

There cannot be any doubt that this end will be attained if only consumers of fuel will allow themselves to be roused from a certain indifference, and, further, there cannot be any question as to the advantages ensuing from work in this direction to individual and community.

The unsatisfactory state of affairs must not be wondered at if we consider how little control is exercised over the supply and consumption of fuel, this valuable and apparently little appreciated portion of our mineral wealth, which supplies civilisation with the energy required for the production of our necessities and commodities, with motive power and with the warmth-giving comfort to our homes.

No supply of gold or other metal, however precious, will satisfy our needs in the event of our fuel deposits being exhausted and other sources of energy not being discovered or developed to an adequate extent.

These considerations make such a control not only desirable, but force their absolute necessity upon us.

With your permission I shall deal with the consideration of the consumption of fuel first.

Time will not allow to enter into a discussion of all forms of fuel, and consequently I have to restrict myself to the most important one—namely, coal.

The use of coal purposes the transformation of its latent energy into the form of heat. Therefore the control of its consumption will be identical with a comparison of the heat abstracted from it under the conditions of a particular case, with the amount of heat or thermal energy it contains.

Let us for the moment assume that we can ascertain this amount of heat and, in general, the composition of a given kind of coal to be burned, say, under a boiler for the purpose of raising steam. If this is known, we know exactly what we can possibly expect from a definite quantity of the same kind.

As I have explained before, when coal is burned in a furnace its combustible constituents, carbon and hydrogen, combine with the oxygen of the air which is brought in contact with it by the draught of the chimney. The resulting products are essentially the gases of combustion which impart their heat to the cool surface of the boiler, thus raising the temperature of the feed water to the degree required for the generation of steam under a certain pressure. With a good design the great bulk of the heat produced should be absorbed in this fashion.

A part of the heat generated is required to evaporate the moisture in the fuel and to raise the coal itself to its temperature of ignition. For, as you all know from the management of the domestic grate, it is only possible to set coal of ordinary temperature alight after properly kindling it with a more inflammable material, such as soft wood or paper.

Another part of the total heat is lost by radiation on to the surface walls, which constantly absorb heat and gradually give it up to the surrounding atmosphere.

What is left of the total, and it is quite a considerable portion, is the sensible heat of the gases entering the flue after passage under the boiler.

If all these factors are added on to the heat usefully absorbed by the boiler, which can be calculated from the quantity of water evaporated, their sum total should equal the total heat ascertained to be present in the quantity of coal burned, possibly less the heat equivalent of any carbon left unburned in the ashes or emitted as smoke or combustible gas.

The ratio found as the result of this "heat balance" of the heat usefully employed for evaporation to the total heat capacity of the fuel burned would represent the efficiency of the boiler.

A test of this kind, which at its best can only be of an approximate nature, is not easily carried out, and cannot therefore be employed as a means of regular and continuous control.

But there is a more direct way of controlling the lines on which combustion proceeds.

The laws of chemical combination permit us to conclude from the composition and temperature of the flue gases how efficiently the process of combustion is conducted.

A very simple analysis of the flue gases, viz., the determination of its percentage by volume of carbonic acid, informs us whether or nor the fuel is burned with a sufficient or with an excessive supply of air. For, knowing the amount of oxygen which has combined with carbon to form the observed percentage of carbon dioxide, and taking the equivalent amount of nitrogen into account, we can, after making due allowance for any oxygen combined with hydrogen, calculate the actual excess of air supplied to the furnace.

The theoretical percentage of carbon dioxide which, in the case of complete combustion of pure carbon, would be 20 per cent. by volume of the total gases, can, of course, never be reached, since a certain excess of air is always required. A percentage of 15, which can be obtained without sending smoke or combustible gases out of the chimney, would be an excellent result; however, 10 to 12 per cent. of CO_2 should be regarded as a good result of average working.

The analysis of flue gases is a very simple operation which can be carried out by any man or boy possessed of some manipulative skill after due instruction and under the control of the trained chemist or engineer, using the ordinary apparatus for gas analysis. However, even this little trouble can be dispensed with, for there are now on the market quite a number of very reliable and fairly accurate instruments which automatically analyse the gases, thus eliminating the human element altogether. Most of them are fitted with recording devices noting the percentages of carbon dioxide and some also those of oxygen on a chart. By this means the superintending engineer can easily find out by the oscillations of the curve produced if his stokers exercised due care in tending the fire. In all cases which have come under my notice has the installing of such appliances been followed almost immediately by a more regular fire practice, more especially during night shifts, which seem to produce almost invariably a less continuous curve during the first period of the working of the apparatus, until the men become wide awake to the fatal accuracy of the method.

In every instance a careful supervision in this direction goes along with considerable economies in the coal consumption, and

a control on these lines with a device of any description, provided it works with a certain degree of accuracy, highly commends itself to any steam user.

Having pointed out the advantages of proper methods of the control of coal combustion, I now come to that of the fuel supply, and hope to be able to convince you that some steps in that direction are urgently required.

The fact that in coal we have to deal with the product of geological changes, probably occupying periods of thousands of years and arrested at different stages of development, will suffice to make it clear to everyone that it is a material of exceptional complexity and of an enormous variety of composition.

I would be carrying coals to Newcastle or to Yorkshire would I attempt to enlighten you on the point that there are differences in quality in the various kinds of coal.

And yet, though incredible as it sounds, the great majority of coal consumers, although possibly recognising the existence of "good coal" and "bad coal," are, to say the least, indifferent to a valuation of their source of thermal energy on a scientifically sound basis. They purchase their coal on the statement of quality by their coal merchant or factor or on the reputation of the mine or district whence it is obtained, and in most cases no specification whatsoever is asked for or furnished.

There is possibly a stipulation in the contract as to the mine or locality from which the coal should come, or else coal "as supplied before" is demanded, but a control of the fulfilment of these stipulations is exercised in only a comparatively small number of cases.

That a control of this kind can be done, and can be done to the satisfaction of all concerned, has been proved beyond doubt by a few private consumers in this country, and by a large body of private individuals and public bodies in various countries abroad.

A great objection which is frequently raised against the testing of coal is the supposed difficulty in obtaining representative samples.

I agree that it is not exactly easy to perform this task, especially where large quantities have to be dealt with. But if you consider that with other mineral products, notably ores, it

has been made possible to obtain samples which truly represent a large bulk, there is no reason why this could not be done with coal.

Every ore, from the most valuable gold ore down to the poorest iron ore which ranks in value about with coal, has to be sampled and tested, and if this operation is performed according to the recognised rules, very good results are obtained. Of course, a margin has to be allowed for the errors of manipulation, but this becomes a more or less definite factor with any material and cannot be a reason for not doing it at all.

The sampling of coal only becomes really difficult when you have to deal with blended cargoes not being homogeneously composed of their different constituents, but in the ordinary case of coals from one particular source, in a fairly uniform physical condition, the errors become extremely small.

In places where mechanical conveyers or unloading arrangements are installed, it is simple enough to discharge periodically from the bulk of the cargo a certain quantity into a sampling-bin by emptying one out of a certain number of buckets. The sampling of railway trucks or barges is done in a similar way by taking small lots from different parts of the bulk. The contents of the sampling-bin, which in most cases would amount to one or two hundred-weights, are crushed as rapidly as possible to a size convenient for making a homogeneous mixture, carefully preventing the loss of moisture during this operation. The whole lot is then divided into four equal parts, two of these are rejected, and the operation is repeated with the remainder until a small sample of five to ten pounds is obtained. This is kept in air-tight receptacles and sent for analysis to the testing laboratory. Here it is further crushed and ground and reduced to a fine powder suitable for analysis.

The tests are usually carried out on the air-dry material; that is to say, the sample as received is, in its original condition, exposed for twenty-four hours to the atmosphere in a dry place, and its loss of moisture carefully noted. Part of the total moisture will be still retained by the sample and can be only got rid of at an elevated temperature.

I have stated before that the principle constituents of coal are fixed carbon, volatile hydrocarbons, mineral matter and moisture. The heat-giving components of the coal are the car-

bon and hydrogen, the latter being always chemically associated with carbon in the form of hydrocarbons, and they form together the pure cool substance. Moisture and mineral matter are very unwelcome companions, for the former has to be evaporated and heated up to the temperature of the furnace, thus absorbing heat; the latter appears as ash, which also has to be raised to the same temperature, and which at the same time is objectionable on account of its preventing the free access of the air through the fuel bed. It also has to be removed at a certain cost from the boiler-house. The further, and perhaps most important disadvantage of both impurities is that they are paid for, weight for weight, at the rate of coal, and yet absorb, instead of yield energy.

It is therefore of the utmost importance to examine coal for moisture and ash in order to be able to determine its value.

The moisture is estimated by heating a small quantity of the sample for two hours in an oven at 105° Centigrade, the ash by igniting the sample in a platinum dish at red heat.

A further test which gives a good indication of the nature of the coals is the so-called coking test. By this the percentage of bituminous matter or volatile hydrocarbons is determined. It is carried out by heating the samples in a covered platinum crucible, subjecting the coal to the treatment it experiences in a gas retort or coke oven. The volatile constituents driven out by the heat escape between the crucible and its loosely-fitting lid and are burned. The quantity and physical aspect of the remaining coke shows the exact nature of the coal, and is most valuable in considering the likelihood of its being a smoke-producing or a smokeless coal.

These tests constitute the "proximate analysis" of the coal and can be amplified in certain cases by a chemical analysis of the ash, which allows a conclusion as to its fusibility and consequent behaviour on the grate.

The ultimate analysis or determination of the elementary composition of the coal is not generally required. Its principal object is the estimation of the exact hydrogen contents. Since the water which is formed upon the combustion of hydrogen has to be kept in the state of vapour in the flues and chimney, the heat thus abstracted must be deducted from the total thermal value to obtain a true picture of the conditions in the furnace. For this determination a knowledge of the percentage of hydrogen is required.

In coal from a certain source the ratio of hydrogen to the total pure coal substance is usually constant, and its determination in such cases can be dispensed with if that ratio is known.

The "proximate analysis" of coal is very valuable in determining the nature and general behaviour of it. It does, however, not indicate the thermal capacity of the coal.

Since fuel is used for its thermal value only, it is most important to obtain information on that point.

Methods of determining the calorific value of combustibles have been worked out in great variety. The principle underlying all these methods is to measure the rise in temperature of a quantity of water to which heat is imparted by the combustion of a definite amount of combustible substance. The scientific unit of thermal value is the calorie, which is the amount of heat required to raise a unit weight of water 1°C. at the point of maximum density. English engineers prefer to take as unit the British thermal unit, which is the amount of heat needed to raise a unit weight of water 1°F. As long as the unit weight of fuel burned to give the increasing temperature of the water is the same as the unit weight of water heated, the relation between the two will be the same as the ratio between the thermometric scales, *i.e.*, a gram or a kilogram or a pound of fuel respectively will heat a like weight of water to the same extent, so that if we find that a kilogram of carbon in burning to carbon dioxide raises 8,080 kilograms of water 1°C., we call that the calorific value in calories, and if we desire to convert it into B.T.U., all that has to be done is to multiply the result by $\frac{212-32}{100}$ or by the factor 1.8, which will give us the rise in temperature expressed in degrees F. when one pound of carbon is burned in a way to impart all the heat of combustion to the same weight of water.

The various methods proposed and employed may be classified into two kinds, those which burn the fuel under pressure and observe the rise in temperature of the cooling water, and those in which the combustion is effected at atmospheric pressure and either the rise of temperature of the cooling water, or, if a constant temperature is maintained, the volume of the cooling water is observed.

In various methods the supply of the oxygen required for perfect combustion is effected by oxidising chemical agents, in others the oxygen is supplied as such in a compressed form.

The best and most accurate calorimeter is undoubtedly the bomb calorimeter originally proposed by Berthelot, the great French chemist, and improved by various workers, notably Mahler, Donkin, and Cook. The modification known as the Mahler-Kroeker type is considered the most accurate, though expensive, instrument of to-day.

It consists of a closed bomb or cylinder in which the combustion takes place in a constant volume. The bomb is made of mild steel, and is platinum-lined or inside enamelled with an acid-resisting composition. For under the pressure employed, viz., 25 atm. of oxygen, the nitrogen contained in the fuel is converted into nitric acid, which would corrode the unprotected steel. The cover of the bomb screws down on leaden joints, whilst two tubes in the cover serve for the admission of oxygen from a steel cylinder. A gauge allows the pressure to be read when filling. One gram of the coal sample is placed in a porcelain or platinum cup, into which dips an iron wire connected to the circuit of an electric battery. The bomb is placed in the calorimeter vessel which contains about 2.25 litres of water, the walls of which are suitably insulated against radiation. The calorimeter water can be agitated by a stirring arrangement.

On closing the current the iron wire is raised to incandescence and ignites the fuel, which burns completely in the atmosphere of compressed oxygen.

The heat is imparted to the water, and knowing the thermal capacity of the bomb and the actual weight of water employed, the maximum rise in temperature observed by means of a very delicate thermometer graduated in one-hundredth degrees gives a value from which the calorific value of the fuel under test can be calculated by a standard formula and after due consideration of certain corrections to be made.

The method has been brought to a degree of perfection, which allows the error in two or more experiments on the same sample to be restricted to as little as ± 10 B.T.U.

A method which gives results of such accuracy—it corresponds to an error of only about 0.1 per cent. or less—deserves to be made use of to the largest possible extent. It not only is accurate, but it gives us a correct picture of exactly that factor for which we employ coal or other fuels, namely, the heat value.

As I have indicated before, other countries are fully alive to the importance of this question of rational fuel analysis.

In the United States fuel experts have gone so far as to propound a scheme, according to which coal is not to be sold by weight, but simply by its calorific value, making the number of B.T.U. it contains, the basis on which price and payment are regulated.

This is perhaps an extreme case, as a lot depends on all the other factors making for the distinctive character of a coal. But the method adopted by the United States Government, not quite so extreme in its principle, certainly deserves mention. As the result of a letter from President Roosevelt to the National Advisory Board on Fuels and Structural Materials, calling attention to the need of a uniform and efficient basis for the purchase of the Government fuel supply, a specification was drafted and approved of by the Board for the fuel supply of all Government offices and buildings. The principal points of this specification is the requirement of a certain standard of coal as regards all its constituents and heating value. These have to keep within certain specified limits, beyond which the cargo is rejected. Within these fairly wide limits a sliding scale regulates the price according to heating value and ash contents of the dry coal. For example, for every 2 per cent. more or less B.T.U. the coal contains, a bonus or penalty of 2 per cent. is incurred. For ash contents above the specified limit a penalty is charged ranging from 2 cents per ton with low ash contents up to 18 cents for coals rich in ash.

A Chicago company, which is said to purchase and inspect nearly 1,000,000 tons of coals for its clients, make the number of B.T.U. the basis of their contract, and adjust the price of these according to the percentage of moisture and ash contained in it.

The Interborough Rapid Transit Co., of New York, in purchasing nearly 400,000 tons per annum, base premiums of penalties on the price at a rate of 1 cent. per ton for a variation of 50 B.T.U.

In Germany consumers have not yet gone as far as our American friends, and although there are occasional contracts effected on the basis of calorific value, this has not become general. But there are quite a large number of manufacturers, ship owners, public authorities, and dealers who demand a guarantee of a minimum calorific value in their coal contracts.

This course seems to be a very reasonable one and works, as I am informed by one of the largest dealers, to everybody's satisfaction.

I do not think that mine owners or dealers in this country will agree in the near future to have anything like the American system thrust upon them. But I cannot see any reason why they should resist the introduction of more rational methods than those at present in vogue.

The consumer who buys the coal for its heating value should see that he gets the value for his money he is expecting. He should insist on having certain properties of his coal supply guaranteed to be up to specification, and should control the uniformity of the deliveries.

I have heard objections against any system of specified coal contracts that the man who is satisfied with a certain coal will continue to use it, and the man who is dependent on a convenient local supply has no choice but to continue his supply.

This latter is certainly in the minority, and even he is by proper testing methods enabled to remonstrate with his contractors should they choose to supply him in irregular fashion.

And the man who purchases constantly from the same mine must bear in mind that not every part of a certain seam would contain coal of exactly the same value, although the type might be the same throughout.

But how should the buyer who has to choose between a variety select that best suited for his requirements ? For him it is most important to know which of a score of different coals would be the one most advantageously to use and would be cheapest for his given requirements of thermal energy, having due regard of special circumstances, probability of smoke production, ash contents, etc.

He would soon find out that a proper control on these lines would amply repay his trouble, and he not only would restrict this control to the supply but, once he recognised the possibilities at his command, he would extend his attention to the careful supervision of his fuel consumption.

On the other hand, the seller of coal will, if he has a good material to sell, not hesitate to guarantee what he is certain of

on reasonable terms, and only that class of traders who so far are able to take advantage of the buying public will resist the introduction of methods which would show their ware in an unfavourable light.

And another and most important advantage would result from the general adoption of such a scheme. By the labours of the Royal Commission on Coal Supply it has been brought to light that the wanton waste which is known to take place with the coal treasure of this country could be considerably decreased if better and more up-to-date methods of raising and preparing coal would be adopted.

No other means would be more practicable than the universal testing of coal to bring home to the mine owner the need for improvements in this direction, showing him the advantages to be gained by applying an improvement factor to his coal by the installation of washing, screening, and classifying plant.

In conclusion, I should like to appeal to you, gentlemen, to give this matter your serious considerations. Many of your public bodies are themselves manufacturers, and all of them coal consumers on the large scale. It should be the pride of any municipal authority to lead the way in advances of this kind. It should be made impossible for local authorities to be entirely in the hands of their coal contractors, and this will be the case as soon as scientifically drawn-up specifications are made the basis of these contracts and their stipulations are carried out and adhered to in a scientific spirit.

TEN YEARS' WORK OF SMOKE ABATEMENT IN LONDON

By H. A. DES VOEUX, M.D.,

Hon. Treasurer, Coal Smoke Abatement Society.

In all business it is customary to take stock of assets from time to time, and it is also useful at stated periods to ponder over the past, and take forethought for the future, to get a good grasp of the present situation, and to settle in one's mind whether one's time has been wisely occupied, whether the right lines have been ruled, and are such as ought to be followed in the future, or whether new methods shall be sought ; and in fact whether changes ought to be made in the management or system.

I thought that this conference would give me a good opportunity of making such a review of the work of the Coal Smoke Abatement Society, more especially as it coincides with the end of the first deceniuum of our work. Ten years is but a short time in the life of a nation, but it is a considerable part of the life of a man and of a new institution, and is of sufficient duration to enable one to sum up pretty accurately the results that have been obtained by one's efforts. And first of all, what did we set out to do ? I will give you the programme word for word as taken from the original leaflet which we published :—

(*a*) To aid in enforcing to the utmost the existing law dealing with the smoke nuisance, which is contained in the Public Health Act of 1891.

(*b*) Where the present law is inefficient to bring about amendment.

(*c*) To enquire into the present causes of the smoke nuisance, and the best means of removing and lessening the same, and to promote the investigation of appliances designed with that object.

(*d*) To obtain evidence of the methods of dealing with smoke at home and abroad.

(*e*) To promote the knowledge of methods by which the emission of smoke may be prevented, and for that purpose to encourage the organization of exhibitions and to stimulate invention by the offer of prizes.

The general effect produced on my mind at the time these paragraphs were written may be summed up in one word—education.

We started our bold and venturesome career at a time when the attitude of manufacturers was distinctly hostile, and that of the general public was apathetic, and when local authorities, in whose hands the application of the law on the subject was placed, from fear of driving away trade, sat with folded arms and deaf ears if a too officious inspector reported that smoke from a chimney had been emitted in such quantity as to be a nuisance. In short, we had to create and lay the foundations on which to work; for it is obviously of no use to think of pictures and decorations for a house, unless the foundations on which it is built are strong enough to bear the strains of wind and storm, such as are likely to be met with in a climate like this. The wind and storm which we were likely to encounter were the strong words of derision and hatred from vested interests, with an occasional snowstorm in shape of an adverse decision in the law courts.

We required foundations very strongly laid, deep, wide and unminable. We therefore drew up careful plans, and slowly but surely proceeded to build; and as we were working underground we did not expect to draw much attention to ourselves, and if I may criticise our action, I think we did too much of the spade-work without sufficiently showing ourselves in the full glare of light. It was not for us, however, to actually diminish the smoke, but to show others how and where it might be done. Our foundations were built of the good material of the five articles of our programme, which were gradually worked up at fortnightly meetings of our committee into a solid mass of fact and information for any other society or public body which required knowledge and guidance.

Our first article (*a*) "To aid in enforcing the law, etc." It was obvious that a small unknown society could not undertake

prosecutions itself, and even if we could do so it would be inadvisable, for we should by so doing fail in our great purpose—education. If we prosecuted, the local sanitary authorities, whose education was most important, would never learn their duty, which the law had laid upon them. Let me here remark that it seems to be generally thought that the enforcing of the Act of Parliament is permissive on the local authority, but the exact contrary is the case. Section 92 of the Public Health Act of 1875 makes it the duty of the local authority to cause inspection to be made with a view to abating nuisances, and Section 94 provides for service of notice requiring abatement.

It is perfectly clear that Parliament was satisfied by the evidence which had been brought before it—and let it be noted that manufacturers have always been well represented in Parliament—that smoke could be abated, and ought to be abated, and that it gave no permissive power to the local authorities whether they would take action or not, but laid upon them the duty of doing so. How have the authorities comported themselves ?

Until our crusade was started it is safe to affirm that not half-a-dozen bodies in the United Kingdom took any action whatever. Our work was at first entirely limited to the Metropolis, and we proceeded not to fight the local authorities, but to make friends with them. But to tell the truth, they are the shyest ladies' men ever made court to—I think municipalities must be feminine—they are shy, suspicious and jealous, at any rate, proud and distant. We had to take off our hats, bow our heads in our courtliest manner, and treat them like sovereign ladies deigning to notice their very obedient and humble slaves. Our plans were quite simple, we appointed an Inspector, Petty—whose name in smoke abatement circles is almost as well known as your Sheffield inspector, Nicholson—whose duty it was to make observations of smoke nuisances and report them to the Committee. Every fortnight we considered these reports, and if the nuisance was regarded as important enough (ten minutes in an hour) it was forwarded to the local authorities concerned, of which we have thirty or thereabouts in London. And this plan has on the whole succeeded admirably, for, headed by the London County Council, which since very early days has been well disposed towards us, and has done enormous good in bringing pressure on laggard authorities, most of the authorities are grateful for our assistance and often appeal to us for help, and practi-

cally all have by this time appointed inspectors whose part or whole duty is to inspect smoke nuisances. Within the county of London there is now little cause of complaint, but outside the county boundaries, where the supervising authority is the Local Government Board, many of the sanitary authorities, headed by West Ham, shamefully neglect their duty. The behaviour of the Local Government Board is disappointing and inexplicable. It has a similar supervising authority for the whole of England as the London County Council has for London, but it remains inactive and unapproachable, in spite of constant and reiterated requests from my Society, and I believe from similar societies in other parts of the country. When the present President of the Board took office we expected great things from him, for as a member of the Battersea Borough Council and of the London County Council, he was as keen on the abatement of smoke as any member of the Society. What a paralysing influence a Government office must have !

What has been the effect on manufacturers and manufactures ? On the whole we are on better terms with those who have abated their nuisance than with those who have not. We have received many reports that the change has been effected with a reduction of expense, which in some cases has amounted to a large sum. The case of the Central London Railway is peculiar and interesting. Two large chimneys from their power works formerly emitted large volumes of smoke daily. A statutory notice from Hammersmith Borough Council having produced no effect, a prosecution and conviction took place in the police court, from which the Company appealed on the ground that, acting under statute, they were bound to run their trains, and that this could not be done without the emission of smoke. The Court of Appeal practically told them that they should have thought of that before they obtained their special Act. It is now on record that while they formerly burnt 1100 tons of coal per week, they now burn 600 tons, a saving of 500 tons. A bonus to stokers of 4s. to 5s. per week is given for saving coal and a fine of 1s. for emission of smoke.

I now give you a few statistics of the chimneys from which we have reported nuisances :—

In the year 1900 we sent reports of nuisances of smoke from the chimneys of 187 premises inside the county of London, while in 1908 we reported only 15 of these premises as creating a

nuisance, a reduction in numbers of 172, or 92 per cent. Outside the boundary in 1900 we reported 49 cases, and of these in 1908 only 14 cases—a reduction of 35, or 28 per cent. The difference in the percentage of reduction is due to the fact that within the county the London County Council can act in default of the proper sanitary authority, while outside the Local Government Board does nothing. It is stated that no prophet hath honour in his own country, but I am pleased to be able to narrate that in the city of Westminster, where our office is situated, we reported 68 premises for emitting in the aggregate 4,231 minutes of black smoke in 1900, while we only reported one of them in 1908 for emitting 13 minutes of smoke.

The reduction in the volume of smoke from factory premises in London is perfectly marvellous, and is well worthy of imitation by other manufacturing towns. It is constantly stated that what has been effected in London is no guide to what could be done in other centres, as the metropolis is not a manufacturing but a residential and trading centre. I am credibly informed, however, that there are more factories, and a greater variety of them, in London and its environs than on any similar area in any part of the world. I know little of the conditions of Sheffield, and gather that in respect of smoke-nuisance it is far better than it formerly was. But I was here on a smoke-abatement errand on a beautiful summer day last year, and regretted that I saw volumes of very dark smoke emitted in every direction. Is this smoke necessary or unnecessary, economic or the reverse ? Have the factory owners done all that science can teach them to abate the nuisance ?—for nuisance even the hardest-hearted of them must allow it to be. Have they appointed a committee of their own members to consider the question, and has this committee consulted the best engineering experts in England ? You have here one of the most beautifully situated cities in one of the most beautiful countries in the world. It ought to be a health resort, and is it ? Nature has given you of the best ; what have you done to improve it ? Much of the smoke here must be emitted from works similar to those in London ; are they in this respect up to London standard ?

The second material for our foundation was (*b*) the amendment of the law where found inefficient. On the whole the law is excellent, and I claim to have shown that where the sanitary authority does its duty smoke nuisance from factory premises

ceases to exist. But there is one flaw in the Act, and that is the qualifying word "black." No smoke is jet black, and much of it is grey, and some very objectionable smoke is yellow. "Black" must have been inserted because it was thought that all smoke was black, but we know that this is a mistake. Smoke gets its colour from the particles of soot from the coal, and if the soot came out in a concentrated lump the smoke might be called black, but even then the colour conveyed to the eye would vary enormously, according to the light, whether the smoke is seen with the sun on it or in the shadow, it would vary with the surroundings and the back-ground and a variety of atmospheric conditions, and I have seen it the shade of pink carnation as the sun was setting on an autumn day! "Black" is inaccurate and unscientific, and many an unscrupulous manufacturer knows how to get over it, and the word must go. It also gives an excuse to laggard authorities, who refuse to act unless their inspector will swear that the smoke is jet black. In London only one other change is required, viz., that the London County Council should have power to act in default of the authorities in Greater London, whose apathy has now been proved.

Through the vigilance of one of our members we were able last year to draw the attention of a Committee of the House of Lords to a clause in the Electric Power Bill, then being considered, which exempted the company from penalties under the Smoke Abatement Clauses of the Public Health Act. The Committee gave a very short shrift to this important clause, and ordered its omission from the Act.

(*c*) Our third material was enquiry into causes of smoke nuisances, and investigation of appliances.

Here we have done great and lasting work, and before describing it I should like to give a word of thanks to Sir Schomberg McDonnell, Secretary of His Majesty's Office of Works, and Sir Henry Tanner, Chief Architect to His Majesty's Government, for the provision of premises on which to conduct our experiments, and the assistance which they have invariably offered us.

We have conducted three series of tests on grates constructed to consume the smoke from bituminous coal. These grates were mostly of the type of modern grate used in the domestic fireplace,

and although some of them were found to emit a comparatively small amount of smoke compared with some old grates, yet—and this I say with deep regret—they all did emit smoke, although stoked with the utmost care, such as could never be bestowed on them under ordinary circumstances. If, therefore, we wish for a completely smokeless city we shall have to banish bituminous coal from the open hearth, and this is such a revolution that we shall have to content ourselves in patience for a time.

Later on we conducted tests on a large number of gas-stoves, and I may say that these were not undertaken with a view to ascertaining which was the best stove, but primarily with the much broader object of discovering whether any of the disparaging statements about gas fires were true. We made the most exhaustive tests on the humidity of the atmosphere, and for the detection of any poisonous gases, and I have much pleasure in reporting that we found that where a gas fire was correctly constructed and properly set in the chimney, and where a sufficiently large pipe was attached to it to carry off the products of combustion, no poisonous or dangerous fumes of any sort were found. Gas burning is, in fact, as free from danger as coal burning, but there is danger from bad appliances, and it behoves all gas companies to see that where gas fires are inserted in a house no danger should occur to the consumer, as the avoidance of risk is easy, if care and thought are expended. This means labour and expense to the gas companies, but they will have their reward in increased consumption of gas and larger dividends.

Then we tested Coalite, that most elusive and fascinating of fuels. Quite easy to ignite, giving a bright hot fire, but burning too fast in some grates, it is too expensive for the ordinary consumer at 30s. a ton. I am still a believer in it, but it is now a year behind time, and I should like to see and hear more of it.

The future of smokeless heating of houses will remain with the smokeless fuels, and not with improvement in grates for bituminous fuel.

(*d*) Our fourth material was to obtain evidence as to the methods of dealing with smoke at home and abroad. Through the kindness of Lord Lansdowne, the then Foreign Secretary, we obtained from the British Ambassadors a full report as to the steps being taken in foreign countries. With the true scientific

spirit of their race, the Germans are dealing with this difficult question in a characteristic way—the Government leading the vanguard. This report is amongst the published papers of the Society.

(*e*) Our last material for foundation was practically the encouragement of exhibitions and the giving of prizes for inventions. We started by giving prizes, and we ended by encouraging exhibitions. The giving of prizes is a great difficulty. To properly test a grate takes a long time, and in our series of tests we found that three days of eight hours were full short for the purpose, and we thought that unless we had more ample means at hand than we have it would be wiser and safer to keep from prize-giving. But to exhibitions, such as the one we are now attending, we give all the encouragement we can, for we thoroughly believe that no more effectual means can be found for enlarging the interest in our movement than an exhibition where thousands see for themselves what each individual can do for the great object which we have in view, and where more especially representatives of sanitary authorities and manufacturers can learn that at any rate in most factories the emission of smoke is as unnecessary as it is wasteful. We wish you all success in your movement, and we express our earnest hope that this exhibition will be the means by which you may be saved some of the great cost which a pall of smoke inflicts on you.

I have now finished my task and should like to draw your attention to one set of figures which alone will show the magnitude of the evil. It is calculated that in London we consume 15,000,000 tons of coal per annum, of which about half is used in factories and half for domestic purposes. It is further calculated that, burning under the best circumstances, at least $\frac{1}{2}$ per cent. in factories and 5 per cent. in domestic grates passes away by the chimneys, and that in London alone, therefore, about 385,000 tons of coal per annum are thrown into the atmosphere—or over 1,000 tons per day. No wonder that God's great sun is angry and displeased, and leaves us in outer darkness; no wonder that statistics show the hours of available sunshine that we lose; no wonder that our houses look grimy and miserable, or that the inhabitants of the poorer streets are pale and gaunt, and their children tuberculous and deformed. I appeal to my audience, whatever towns they come from, to do

their best to call attention to this problem, to start where they can smoke-abatement societies, on which should be represented not only the local authorities, but manufacturers and scientific engineers. An ideal society would be one of citizens, manufacturers, and sanitarians, with an inspector to report nuisances, and two or three engineers, whose duty it should be to recommend the proper appliances for combustion of fuel.

I feel certain that if any great municipality were determined to get rid of this horror, were to throw away the childish pride which prevents it from asking outside aid, and would appeal to the general body of citizens to make one great united effort by the formation of such a committee, it would succeed to such an extent as would astonish the world, and earn the thanks of the countless inhabitants of our great manufacturing cities.

THE PRESENT SITUATION AND OUR IMMEDIATE DUTY

(Summary of Address)

— BY —

JOHN WILLIAM GRAHAM, M.A.,

Principal of Dalton Hall, Manchester.

Mr. Graham did not speak from a manuscript, and only the following summary of his speech is now recoverable :—

He concentrated attention on the next things to be done ; on the practical steps forward which were immediately possible. First, with regard to law and administration, and, secondly, with regard to material improvement in fuel.

The present Public Health Acts were disregarded over the larger part of England ; only in London and seven large municipalities did the local authority attempt to put the law in force to any serious extent. To those municipalities, however, much credit was due for the public spirit they had shown under much discouragement from the magistrates, for, it must be remembered, that every local authority or smoke inspector, however zealous, had to come before the magistrate before he could obtain a conviction and a fine ; and when the health officers, after a troublesome conflict, succeeded in proving their case against a wealthy manufacturer, the fine of a few guineas was mere trifling with the issue, and ought to be very greatly increased. But the magistrates were often gentlemen who themselves lived in clean and beautiful places ; had, perhaps, made money in a smoky business in which their relatives were still engaged ; they were not popularly appointed, and nothing but an improvement in public opinion would remove their passive opposition to reform. The apathy of most local authorities, which is due to the same personal considerations as that of the magistrates, could only be removed by putting smoke under Acts like the Alkali Acts, whose management was in the hands of competent

and well-paid scientific inspectors, each responsible for a large area, and able to advise manufacturers in a spirit of co-operation and with extensive knowledge. The inspectors under the Alkali Acts, from being regarded as the enemies of manufacturers, were now regarded as their friends.

For both manufacturing and domestic smoke cheap gas was the most immediate palliative. There was no reason why over the smokiest parts of England gas should not be sold at 1s. 6d. or 1s. 9d. per thousand cubic feet. At this figure it was as cheap for power as coal. Instead, however, of selling as cheaply as possible this clean fuel, municipalities were in the habit of making what they called a profit out of their gas consumers for the relief of their ratepayers. This policy had many disadvantages. It unfairly taxed the keepers of factories and shops, who use gas largely, for the benefit of the owners of cottage property, who pay their rates, and of the users of oil and electricity. These fictitious "profits" pay income tax, apparently for the pure pleasure of book-keeping. But, above all things, this policy prevented the cleansing of the atmosphere, for the amount of gas which would be used for power and for cooking and for heating, if gas were 1s. 6d., would be enormously greater than it is with gas at 2s. 6d.: it would make all the difference in numberless cases. In reality gas consumers ought to be rewarded for the relief which they give to the cost of the cleansing of the city and to the public health. Further, the indirect acquisition of money for the rates tended to extravagance in municipal expenditure.

[Since this address was given, it is encouraging to note that a Parliamentary Committee has refused to allow the Corporation of Salford to continue this practice to any large extent, and, acting on the hint, the Corporation of Oldham has withdrawn the clauses in its gas Bill which asked for similar powers.]

The other ground of hope—and the one present and complete solution of the domestic smoke problem—is to be found in coalite. It had in it, the speaker believed, the promise of a completely satisfactory fuel. He held no brief for the Coalite Company, and had no interest of any kind in it: no doubt that Company would itself look to the validity of its own patents, on which he expressed no opinion; but there could be no doubt that coalite was absolutely smokeless, and he had reason to believe that it could be produced as cheaply as coal. It would have to be done through the co-operation of the gas companies, and, happily, the gas

company at Plymouth had entered into an arrangement with the Coalite Company by which they bought from it the twenty-candle-power gas which it produced. The experiment was, so far, very successful at Plymouth. The Coalite Company had been spending its time in improving its apparatus, of which the essential principle is that the distillation of the coal shall be done at a low temperature, so as to leave in the coalite a considerable quantity of the hydrogen and other gases which are usually taken out of it in carbonisation. The temperature required being low—in fact, not being enough to make the coal red hot—the coalite process required much less coal to keep its retorts hot. Whilst in ordinary gasworks 16 per cent. of the weight of coal carbonised is used to keep the fires up, coalite only requires 6 per cent. as fuel. By making cheap nine-candle-power gas out of some of the coke and tar produced and mixing it with the 20 c.p. gas, there resulted rather more gas of the usual fourteen-candle-power than is produced in the ordinary way; we have coalite instead of coke in equal weights and much more tar, of a higher quality, and containing expensive ingredients. There seems but little good reason why this product should not be made at all the gasworks in the country and sold at a very low price.

SOME ASPECTS OF THE SMOKE MEASUREMENT PROBLEM

— BY —

JOHN S. OWENS, B.A., A.M.Inst.C.E., M.D., F.R.G.S., &c.

My reason for choosing this subject to address you on is that I am at present engaged in carrying out some experiments in smoke measurement for the Coal Smoke Abatement Society, London, whose public-spirited interest in the question caused them to commission me to make investigations. Also, I have had the privilege of carrying out several prolonged tests of fires, stoves, fuels, etc., for the Society, and have always been struck with the necessity for some more accurate method of measuring the smoke than any adopted up to the present. As the experiments above referred to have only recently been commenced, there are not many results to place before you. My paper may therefore be considered rather as a plea for more attention to this subject, and for the adoption of some standard method of measurement.

It must be obvious to anyone who considers the matter that the whole question of smoke measurement is in a very unsatisfactory state. Nothing is settled or agreed on generally, and each sanitary authority, or other body interested, uses the method which appeals to it most, irrespective of the methods which may be in use elsewhere. It therefore seemed to me that a short summary of the best known present methods of measurement, with their advantages and drawbacks, would be of interest to the Conference.

Attempts to measure smoke may be roughly divided into two classes:—One, in which no effort is made at exact estimation; but simply a comparison with some arbitrary standard of shade or colour, the smoke being viewed as it escapes from the top of the chimney. The second class covers attempts to measure accurately the proportion of the fuel which is wasted in smoke.

In the first group the intensity of the shade of the smoke is compared with what is usually termed a smoke scale, of different degrees of darkness, either printed on a white background or in the form of smoked or neutral-tinted glasses.

I will now refer briefly to some of the scales and instruments which have been tried.

The Manchester Smoke Abatement Committee of 1881 used a scale of ten shades of grey.

The English Smoke Abatement Committee of 1895 used four shades on their scale.

In the Paris smoke tests of 1897 five shades were used; the apparent densities were plotted on a rotating drum at half-minute intervals, giving a curve, the area enclosed by which was taken as a measure of the density of the smoke.

The Prussian Commission of 1894 used an elaborate photometric method, comparing the varying intensity of a ray of artificial light passing through the smoke with a scale, the smoke being examined between the boiler and the chimney.

The Ringlemann smoke scale has six shades, numbered 0 to 5; they are made by ruling black lines on a white background, two sets being ruled at right angles. This scale must be viewed from a distance of about 50ft., and usually requires two persons to make an observation, one to hold the cards, which are very large, and one to compare them with the smoke. The shades are obtained by ruling lines of different thickness as follows:—

Number	0 is white.							
,,	1 has black lines		1	mm. thick	and	9	mm.	apart.
,,	2	,, ,,	2·3	,,	,,	7·7	,,	,,
,,	3	,, ,,	3·7	,,	,,	6·3	,,	,,
,,	4	,, ,,	5·5	,,	,,	4·5	,,	,,
,,	5 is black.							

Bryan Donkin's scale, like the last, has six shades, 0 to 5, and white to black. They are of the same intensity as the Ringlemann shades, but of a uniform grey colour, so as to be viewed from close at hand.

The Coal Smoke Abatement Society, London, has adopted a scale of four shades, "pale grey, grey, black, and dense black." In this and the last there is always some difficulty in printing, as

it is hard to get always exactly the same shades. Also there is a tendency to fade with time, and to take on a yellowish tint. The Society has tried many ways to overcome these difficulties.

The Public Health Department of the Corporation of London adopts a scale of nine shades of grey, from white to black.

Photographic methods of registering the shade of smoke have been tried, but without any conspicuous success. A photograph sometimes gives a very false impression of the colour of smoke; in fact, it has been shown that a chimney which has no smoke issuing, but only a stream of hot gases, will sometimes come out in a photograph with a dense column of smoke, to all appearance, blowing away from the top.

Turning now to instruments for smoke measurement, the following may be mentioned:—

An American instrument consisting of a disc containing neutral-tinted glasses, or smoked celluloid of different shades, each glass having a central hole. The disc rotates on the end of a tube, and the smoke is observed through the hole in the smoked glass, the disc being moved until a shade is found corresponding to the smoke.

Lovibond's Tintometer consists of a tube having two $\frac{1}{8}$-inch holes $\frac{1}{2}$ inch apart in a diaphragm inside; the smoke is observed through one, and slips of neutral-tint glass are placed in grooves opposite the other hole, until a correspondence in shade with the smoke is obtained. In this the glass is observed by the medium of light reflected from a slip of matted white opal inclined at an angle in front of it, so as to obtain a uniform background. In both this and the last instrument nothing is attempted beyond matching the smoke in shade or colour.

In an instrument which I have devised, five neutral-tint glasses are fixed in a revolving disc on the end of a tube, and numbered in the order of their density from 20 to 100. The smoke is examined through a central hole $\frac{1}{8}$ inch diameter, and matched to a glass by revolving the disc. On the body of the tube are numbers giving the observed density divided by the diameter of the chimney, and thus the true relative density of the smoke; or, if so calibrated, the weight of soot present per unit volume of flue gases.

There are considerable possibilities of error in all these instruments. My own is an attempt to advance the matter a little by allowing for the thickness of the layer of smoke looked through.

The mere comparison of the blackness of smoke by eye with an arbitrary scale does not give satisfactory results, the greatest fault being that chimneys are compared without reference to their diameters. There is also much room for error from the personal factor, smoke appearing of different shades to different observers. Again, the presence of wind, the direction of the line of vision relative to the smoke column, the colour of the background, all influence the result. In the American instrument and my own, the errors due to background are eliminated as far as possible, as the smoke and shaded glasses are viewed against the same background. In comparisons with a paper scale, we view the smoke chiefly by transmitted and the scale by reflected light. This is a great source of error; the background of the smoke varies, that of the scale being fixed. I believe that both smoke and scale should be looked at by transmitted light from the same background.

Turning now to absolute measurement. The attempts which have been made to determine the percentage of the weight of the fuel which is lost in soot have been many; and they are characterised by a remarkable want of agreement as to the results. The method commonly used is to aspirate a measured volume of the flue gases through a filter, of asbestos or cotton wool, and to weigh the carbon dioxide produced on burning the filtrate, or the actual matter trapped.

Other methods tried have been the precipitation of the soot by means of low-pressure steam, or by static electricity, sweeping out the flue before and after burning a fire for a certain time, and weighing the soot; this, of course, takes no account of the soot escaping into the air. It is with reference to the method of filtering a measured volume of flue gases that I am at present experimenting for the Coal Smoke Abatement Society.

The chief objection to the filtration method lies in the fact that we cannot be sure of getting a representative sample of flue gas, as far as soot is concerned.

Scheurer-Kestner, adopting this method, concluded that ½ to 1 per cent. of the fuel in boiler furnaces was lost in smoke.

Professor C. Roberts, at the Manchester Smoke Abatement Exhibition of 1882, got in one case by the filtration method, according to the published figures, more soot than there was coal burnt. In another case the soot was 40 per cent. of the fuel.

Professor Cohen, in testing open-house fires at Leeds, got about 5 per cent. of the weight of the fuel in soot.

It is unnecessary to instance other cases, as I merely wish to show the different values for soot which have been obtained.

Much appears to depend on the direction and shape of the inlet to the filter and the velocity of the gases entering. The position in the chimney, both as to distance from the fire and the part of the cross section from which the gases are drawn, is also of importance. If too near the fire the soot will not be mixed properly with the flue gases; if at the top of the chimney, there will also probably be unequal distribution of the soot owing to the greater velocity of the gases at the centre than at the sides; also the soot adhering to the sides is neglected. I attempted to detect the uneven distribution in a small experimental chimney, 3¼in. in diameter and 11ft. high, by filtering the same volume of gases from the side and the centre at the same time in similar filters; but the results have not, so far, given a very clear indication. I believe that in large chimneys there would be a considerable difference. In one experiment, made this week, I filtered 44 litres from the side and 45 from the centre of this chimney; in the former I caught 0.0888, and in the latter 0.0844 grammes of sooty matter. When corrected for the unavoidable difference in volume these are in the proportion of 108 from side and 100 from centre.

The percentage of the weight of coal burnt was about 1.6, and the smoke was never black, but of a yellowish-grey, about No. 2 of the Ringlemann or Donkin scale. There was also some soot deposited in the chimney, as the filters were 10ft. from the fire.

In another test with the filters 4ft. from the fire, I got a percentage of about 2.5 of the coal; and the difference may be partly due to soot deposited in the chimney, although the experiments have not proceeded far enough yet to draw definite conclusions from. This question of the distribution of the soot on the cross section of the chimney is one I am investigating for the Society, as it bears on the value of the filtering test.

The actual amount of fuel lost in smoke cannot be very great, relative to that burnt; although in the aggregate it is important and amounts to many thousands of tons per annum in London alone.

A continental lampblack factory recovers only 3.3 per cent. of the weight of the coal burnt, in lampblack; but, although as much smoke as possible is produced for the purpose of making lampblack, it is of the sooty as distinct from the tarry variety; and the latter plays an important part in smoke from ordinary fires. We must not therefore regard 3.3 per cent. as the maximum obtainable amount of smoke.

Professor Roberts, in his Manchester experiments of 1882, by sweeping out the flue of an open fire obtained 2.25 per cent. of soot, and in other cases from 0.05 to 0.5 per cent. of the weight of the fuel, so that the total amount produced must be much greater than this.

In conclusion, I would suggest that some attempt should be made by the different societies and local authorities concerned to come to an agreement as to a method of smoke measurement to be generally adopted in practice; in short, to agree on some standard, so that it will be clear what is meant when smoke of a certain density is referred to. I do not suggest that elaborate methods, suitable only for the laboratory, be adopted, except in special cases, but that some universal standard be agreed upon which will be as accurate as the conditions permit.

I see that at last Monday's meeting it was decided to form a committee to consider the question of smoke abatement generally, and as I intended myself to suggest the appointment of such a committee to consider and investigate the subject of smoke measurement, I would now propose that this question of investigation and standardization be one of the first to occupy the attention of the committee which has been decided upon.

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THE COAL SMOKE ABATEMENT SOCIETY

ADDRESSES, PAPERS,

AND

DISCUSSIONS

At CONFERENCE on SMOKE ABATEMENT, London, Dec. 12-15th, 1905, arranged by The ROYAL SANITARY INSTITUTE and the COAL SMOKE ABATEMENT SOCIETY

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CONFERENCE ON SMOKE ABATEMENT.

PRESIDENTIAL ADDRESS

By Sir OLIVER LODGE, D.Sc., LL.D., F.R.S.,
Principal, University of Birmingham.

Delivered December 12th, 1905.

IT is very appropriate that The Royal Sanitary Institute should have joined with the Coal Smoke Abatement Society to summon this conference, held under their joint auspices, for nothing can be more insanitary in the long run than the sun-obscuring atmosphere in which we artificially arrange to live. Those who try to imagine that coal smoke exerts a disinfecting influence are deceiving themselves. The amount of disinfectant fatal to disease-germs would assuredly also be fatal to higher organisms; and, besides, who wants to live in the midst of a plague of disinfectant, diffused through the common atmosphere, any more than in a plague of anything else?

Moreover, coal smoke contains many other products besides coal tar, asphalt, manures and other useful material, it contains sulphurous acid, an ingredient of the most noxious character, which speedily becomes oxidised into oil of vitriol. But all this is well known and commonplace, although it can hardly be repeated too frequently so long as the barbarous combustion of crude coal in a savage and unorganised manner is permitted in the midst of the semi-civilisation we have so far attained.

Assuming that people are awake to the evil, the problem is to find out a remedy. One remedy that has been suggested is the electrification of the air on a large scale, a plan which I have brought within measurable distance of application, and believe to be the appropriate method of dealing with river and sea mists and other temporary obstructions to traffic, and in general of dealing with fogs of a non-avoidable kind. But if it did not need so much capital to try it on a large scale, I would certainly seek to try it as a temporary measure for some parts of London. It ought also to be useful for the deposition of valuable metallic and chemical fumes, the product of manufacturing processes.

But as a permanent method of dealing with town fog caused by imperfect combustion it would be a very expensive method. It is expensive to produce a town fog, and it would be expensive to dissipate it. The double expense ought not to be tolerated. The right way of dealing with a town fog is not to produce it. If it were only country mist it would not be nearly so deleterious: it would be disturbing to traffic, but it would not enter houses nor lungs, consequently it would do no particular harm, and, moreover, it would soon be dissipated. But the fog which contains products of imperfect combustion is in the first place far denser, in the second place far more readily formed, and in the third place much more permanent. No ordinary warmth will evaporate it and it retains its character even in houses and in lungs, where it causes a dirty and damaging acid deposit.

The right plan is not to produce it, that is to say, not to permit imperfect combustion in large cities, but only to permit combustion planned and executed in such a way that no half-burned products shall escape, and likewise to insist that the material burned shall attain a moderate average of purity, the amount of sulphur especially being kept down, since sulphur is even more noxious when thoroughly burned than when half-burned or not burned at all, thus constituting an exceptional case requiring special attention and treatment.

Problem of Combustion.

To take the problem of combustion, therefore, there are three things to be attended to:

1. Purification of the material to be consumed.
2. The proper means of effecting its complete combustion under conditions of easy regulation and avoidance of dust and dirt.
3. The utilisation of the heat due to that combustion without waste.

1. The scientific and satisfactory combustion of crude coal as it is dug out of the pits is an impossibility; it must first be subjected to some chemical treatment. Its solid and its gaseous constituents ought to be separated from one another. The solid constituents in the form of coke, when properly made, are of exceeding value for smelting and manufacturing operations, and it is the solid portions which will contain the ash and dirt.

The processes involving the use of solid fuel should not be carried on in a big city, but should group themselves round a coalfield, so that the cost of carriage may be small.

The gaseous product, on the other hand, readily lends itself to purifi-

cation and chemical treatment, and can then be *easily transmitted to any distance*, and there burned in a scientific and proper manner under easy regulation, being turned on and off as wanted.

Another scientific method of dealing with coal is to turn almost the whole of it into gas, *i.e.*, all except the ash, by a judicious supply of air and steam, and then to utilise the whole of this gaseous product, purified up to a certain point. Gas of this kind, sometimes called water-gas, sometimes producer-gas, sometimes Mond-gas, according to various details of its preparation, can be made very cheaply and plentifully; but its large amount makes purification of it rather more difficult, and moreover it has not the same heating power, bulk for bulk, as coal-gas proper possesses, without so great an admixture of nitrogen. However, all those details are matters for careful consideration. There are advantages and disadvantages in every plan that has been suggested; but there is not one plan for the combustion of gas that does not far eclipse the uncivilised and essentially savage method of heaping a pile of crude coal together and setting a light to it.

Consider what the burning of coal in a city means:

1. The getting of coal in the pit.
2. The raising of it to the surface.
3. The loading of it into railway trucks.
4. The unloading of it on wharves.
5. The shovelling of it into carts or sacks.
6. The carrying of it on men's backs or wheelbarrows and storing it in coal cellars.
7. The shovelling of it into scuttles and carrying about the house.
8. The putting of it by hand on to fires.
9. The distillation of a great part of it up the chimney, and the half-burning of the rest.
10. The raking out and carrying down of the ashes.
11. The carting of them away and dumping them to form the foundation of a future house.

A long and troublesome series of operations even apart from the fouling of the air, which has not been mentioned, but which is the worst condition of all.

Now consider what the supply of gaseous fuel would entail:

1. The getting of the coal as before.
2. The conversion of it into gas, either at the bottom of the pit or near its mouth.

3. The conveying away of the coke and the manure products to where they are wanted.
4. The transmission of gas in great pipes to the distant town, just as water is now transmitted; with such occasional pumping stations as may be necessary, driven by the power of a small portion of the same gas.
5. The underground distribution of all this fuel, and its utilisation by the turning of a tap, in a manner which will insure complete combustion, with no smoke, no ash, no dirt, no trouble and no residual product to carry away, either in carts, or clothes, or lungs.

Against all these conveniences we have to set the influential and constantly-encountered parrot-cry, "We do not like gas fires." The people who say this do not realise that every coal fire is to some extent a gas fire, though a very bad one. When coal is put on, a quantity of it is necessarily turned into gas—impure and badly-made gas, but gas at any rate, which before long catches light and flames, burning with a smoky flame, but burning and giving what is called a coal fire, though it is really a gas fire, the gas being made on the premises, and made badly, and only half burned because mixed with carbonic acid from the red-hot material below. There is some justification, however, for the prejudice, of course; and the justification is that when people speak of gas fires they think of the imperfect arrangements at present in vogue for burning gas at 3s. or 3s. 6d. a thousand; burning very little of it therefore, and burning that imperfectly, sometimes without causing sufficient draught in the chimney to carry away the products of combustion, which therefore enter the room. When the products from a coal fire enter the room people say the chimney smokes, and regard it as intolerable; but when the same thing happens from an imperfect gas fire they are liable to abuse gas fires in general, as if the defects were a necessary condition of their existence. Moreover, some people go so far as to put a gas fire into a chimney which has troubled them by smoking, because, the products being invisible and somewhat less noxious than the coal fire products, they think they may be tolerated; though at the same time the reputation of the gas fire suffers irretrievably.

None of these things would happen if gas were supplied in large quantities, for use all day for cooking and heating purposes at a very low price. Sufficient would then be burned to make the chimney draw properly, and the general use of such arrangements would stimulate invention to the production of appropriate gas fires, such, for instance,

as some of those used in Pittsburgh, where natural gas is, or was, cheaply available, and where no one thought of burning coal.

It would seem to be wise for municipal authorities or others interested in gas to superintend the proper erection of gas fires, and to encourage their use by supplying them cheaply and inspecting them gratis if inefficient.

2. But now what are the conditions of complete combustion? First of all there must be no cold surfaces to interfere with ignition. Gas must be raised to a certain temperature before it will ignite, the simple theory of a flame is that the combustion of each portion has to ignite the next; and it cannot do that if the temperature is lowered beyond a certain point by cool solid conductors introduced into the flame. In many domestic grates there is far too much iron: there ought by rights to be none, nothing but non-conducting material, within reach of the flames, otherwise the portion of the flame in contact with the good conductor is necessarily extinguished, whether visibly extinguished or not, and the material escapes unburned.

Because the products which escape up the chimney are invisible, it does not follow that there has been complete combustion. Many of the products of incomplete combustion are gaseous, and it is just as wasteful to allow chemically combustible material to escape unconsumed as it is to allow heat to escape when it has once been generated by combustion. This fact is, however, often forgotten, and so long as all the heat generated is utilised, it is thought that there can be no waste. On the contrary, there can be very much waste, and in many cases there is. This matter is so important that it must be illustrated by experiment. The avoidance of cold surfaces in open fire-places and stoves is not difficult, and there is no excuse for them there, nor is it difficult to avoid them in many manufacturing processes, such as the baking of pottery and other furnaces dealing with incandescent material.

But there is one great application where the introduction of cool surfaces into the flame seems almost unavoidable, viz., the *firing of boilers.* It is to be hoped that gradually gas-engines will replace steam-engines and enable us to dispense with the rather primitive and unsatisfactory arrangement of obtaining power by the boiling of water. It is *impossible* to transfer heat with real economy from a furnace into a boiler. It is usually thought to be sufficient if all the heat generated is absorbed by the boiler, though even that is never fully accomplished. But suppose it were accomplished, there would be two great sources of loss still left ignored: one is the escape of unburned material already mentioned, and the other, and

much greater in amount, is the drop of temperature between furnace and boiler, concerning which there is much to be said, but briefly this: that it alone entails a loss of a great amount of available energy, more than seventy per cent. of the whole, for which there is nothing whatever to show.

Another condition for complete combustion is the adequate supply of air, unmixed with carbonic acid or other material. If enough air is not supplied, then the fire, stove or furnace becomes a sort of gas retort, the only difference being that in a gas retort no air is supplied at all, and the products are simply distilled away unburned. This happens in the early or black stages of a coal fire, but it is especially liable to happen in closed stoves and in other furnaces with doors. A quantity of coal is put on and gives off gas which bursts into flame, then the door is shut, the flame promptly goes out, and the gas is distilled up the chimney. If the door is opened it may catch alight again with a small explosion. Consequently the stoker takes care not to open the door until the gas is all gone and he is left with nothing but smouldering coke. Then he can open the door and repeat the process. The amount of senseless incombustion that goes on in common hand-fed stoves is something almost incredible, and only to be accounted for by a recognition not only of the dense ignorance of the uninstructed human race but by its obstinate stupidity also in being unwilling to learn, and thinking that its own habits are perfect and unimprovable.

Furnace stoking is managed much better, for its evident importance has directed a considerable amount of scientific attention to it. It is known that fresh fuel must be introduced either under or in front of a burning and red hot mass, so that the products of distillation may be raised up to combustion temperature before they escape. It is known also that sufficient air must be admitted if they are to be properly burnt, and that this air ought properly to be warmed by waste flue heat before introduction. Automatic stokers are made to continually feed in fresh fuel in the right place and way, but probably no automatic stoker can compete with highly intelligent hand feed. Stoking is an art, and a good stoker is a skilled artizan well worthy of appreciation.

In boiler furnaces, however, there is this difficulty, that if too much air is introduced combustion is too perfect, and the flame has insufficient *radiating power*. Moreover, even though the air is previously warmed up, as it ought to be, it exerts a considerable cooling influence, the cooling being mainly due to the great bulk of nitrogen in proportion to the active ingredient of the air.

3. The utilisation of the heat produced in boilers is most important, and demands illustration.

Heating by Radiation.

The right way, and indeed the only way, of conveying heat from a flame to a cool surface is by radiation. It is impossible to bring a flame into contact with a cool surface: the flame is extinguished where it touches, and a layer of non-conducting gas necessarily intervenes, across which the heat can only pass by radiation. Accordingly a luminous and somewhat smoky flame is necessary inside a boiler, unless the walls of the boiler are so thick or so covered with studs that the surface exposed to the flame may become red-hot and above the temperature of ignition. In that case the flame need not be extinguished, but may play upon them properly. This is a condition hard to satisfy, however, and so in some cases a luminous and to some extent smoky flame is necessary, and the combustion must be completed by air introduced beyond the boiler and before the smoke-stack.

A better plan is to introduce special solid material into the flame and keep it at a white heat so as to utilise its radiating power, on the principle of the gas-"mantle." A mantle radiates far more heat than even a luminous flame, and immensely more than the blue flame of perfect combustion; but the blue flame is the right one for keeping solid materials thoroughly hot, and these solid materials may in some cases be the walls of a combustion chamber, provided that the boiler surfaces are exposed to its glare. I shall not mention any specific device; I am dealing only with general scientific principles, but it is well known that more or less efficient methods of effective boiler-firing are growing in number. For steady work some of them suffice, but the difficulty of regulating the combustion of a coal-fed boiler under variable conditions is excessive; and whereas with a gas-fed boiler it would be easy to turn the gas on and off, with a coal-fed one the fire has to be banked up and kept in a black condition when not wanted, which is exactly the condition for smoke and destructive distillation without combustion.

There are many more things to say, and some points need more detailed treatment. Boiler furnaces are the only really difficult problem. Separate combustion chambers should be used for tubular boilers, so that cold surfaces shall not put out a flame. The radiating power of solid particles in flame is important, but the main moral is: Don't allow crude combustion of coal in towns, but supply them all day long with cheap gas from a distance.

IS LONDON FOG INEVITABLE?

By W. N. SHAW, D.Sc., F.R.S.
(F.R.SAN.I.)

THE consideration of this question has an important bearing upon the more immediately practical question of the abatement of coal smoke. No one will assert that there is anything physically impossible in the idea of dispensing with coal smoke. To find a substitute for our accustomed methods of warming and cooking (using the latter word in its widest sense), may be difficult or costly, but it is not impossible. But there may be some who are of opinion that if there are to be fogs in any case, the effort necessary to keep them clean is not worth the trouble and expense, and a review of certain facts and speculations which bear upon the question may be of some assistance.

Much work will have to be done before we can place our views of questions concerning fog beyond the region of speculation. Mr. Brodie, of the Meteorological Office, in a paper read last year before the Royal Meteorological Society, and discussed during the incidence of an unusually intense fog, gave statistics to show that there was in late years a decline in the frequency of fog in London; but whether that decline was due to a diminished number of occasions on which fog was meteorologically possible, or a diminished propensity in the London atmosphere to take advantage of such occasions, was not settled. There is no uniformity of practice as to the condition of the atmosphere that should be classed as fog. We do not know the actual course of events in the physical processes comprised in its origin and persistence, and until that stage is reached by patient experiment and close observation, the limitation of our power of dealing with such a question as that which forms the subject of this paper must be somewhat narrow.

A beginning was, however, made a few years ago on behalf of the Meteorological Council, with the material assistance of the London County Council, by Captain Carpenter and Mr. Lempfert, during the winters of 1901–2 and 1902–3 respectively.* Their reports enable us to

* "Report of the Meteorological Council upon an Inquiry into the Occurrence and Distribution of Fogs in London," 1904, and "London Fog Inquiry, Report to the Meteorological Council," by Captain Alfred Carpenter, R.N., D.S.O., 1903.

be more precise in matters concerning fog in London than was previously possible. In the first place, a scale of classification of fog by its effect upon traffic has been drawn up, and may be commended to those who desire comparable statistics for economic purposes. There can be no doubt that when we unexpectedly encounter a tramcar on the footway at a time of broad daylight, a fog which accounts for the incident may be called a thick one. It marks the complete paralysis of traffic, and in the country, when road margins are indistinguishable, and people lose their directions on account of fog, a high figure is rightly used to denote it. There are various gradations from this thickest fog, through the persistent smoke haze of the London streets in winter, to clear atmosphere. Of these intermediate gradations, the fog scale arranged by Captain Carpenter marks four, by the effect upon road and river traffic, for the purpose of classification, giving in all five numerical categories for the classification of fog. A considerable difficulty in forming a traffic scale of fog arises from the combination of fog with darkness. This difficulty is greater in the country, where there are no road lamps, than in towns with regular street lighting; but even in London the demoralisation of traffic becomes accentuated as darkness comes on at the close of a foggy day. Consequently some judgment and experience are required in estimating the density of fog on the traffic scale, 1 to 4, between 0 ("clear") and 5 ("street traffic impossible").

Captain Carpenter came to the conclusion that in the winter London was never free from a smoke haze; for some months of the winter when he was in charge of the observations, St. Paul's was invisible from the Victoria Tower, and although in the following year conditions were more favourable, there is no doubt that the entries of light fog (1 or 2 on the traffic scale) would be more frequently noted in London or other large towns than in the country, and that the abnormal frequency is due to smoke. Thus many light fogs may be attributed to smoke alone.

To form an estimate of what would be left if the smoke could be otherwise disposed of, we have to determine the cause of the formation and of the persistence of fog. This involves the identification of an extremely complex physical process comprising the cooling or warming of the air and the earth's surface, the supply of moisture and the prevalence or absence of wind, and this process has only been partially traced out in its details in actual practice.

The most frequent cause of fog is the cooling of the surface by radiation under a clear sky. As the air gets cooled by contact with the cold surface it flows gradually downward like a sluggish river slowly but surely

finding its way to lower levels. There is no limit to the extent of country which may be covered by this process. Just as nearly the whole of these islands was at one time covered with a coating of ice and snow that slowly worked its way towards the valleys, so at any time it may be covered with a vast sheet of cooled air slowly descending and becoming still colder as it descends, unless further radiation is prevented. Fog will form in the descending air if it becomes cold enough to go below the dew point. If the ground has been saturated with rain before the cooling began the dew point will be high and the formation of fog is all the more certain. Out of the thirty-nine cases dealt with in the winter of 1902-3 Mr. Lempfert assigns twenty-four to the effect of radiation of the kind mentioned, three to the slow passage during a change of weather of warm air over the surface which had been previously chilled, and four to the formation of cloud above the surface; eight he considered as consisting practically of smoke and nothing else.

Thus if the figures for that particular winter can be accepted as a guide, the Smoke Abatement Society has about twenty per cent. of London fogs to deal with absolutely, as the lawyers say. The remainder depend upon physical processes which are not within our control.

But from a certain point of view it may be said that the gradual extension of the London building area ought to tend towards the diminution of fog in London as compared with the country. One of the definite results of the fog inquiry is a recognition of the great prevalence of fog in the parks and open spaces, where the herbage and shrubs and other projections are cooled by radiation without any compensating warming from the ground, and thus they act as cooling agents for the air. A wood pavement if it is dry becomes similarly very cold on clear nights, but generally less so than the grass. House roofs become generally less cold than a dry wood pavement because they are kept warm from below. Thus one of the compensations for the diminution of open country in the immediate neighbourhood of London ought to be a diminution of the area in which radiation fog is formed most easily. London has now become so large that it is possible that this restriction of the conditions favourable for the formation of radiation fog has already produced a measurable effect. But such fogs are sometimes very wide spread; they may extend from the Mersey to the Thames, as they did in December of last year, and as the chilled air which carries the fog is always flowing gently downwards, it will collect in the great river estuaries. Thus we can scarcely hope that freedom from smoke will give us complete immunity from the fogs due to radiation.

Our knowledge of the conditions necessary for the dispersal of fog is still in a very primitive condition. In the Council's Report on London fogs it was suggested that the formation of fog tended to prevent the further cooling of the air near the ground, because the fog itself acted as a sort of blanket, and protected the surface from further chilling radiation. This idea seemed to be supported by the practice in vogue in the United States of making an artificial screen of smoke to cover the fruit trees as a protection against frost on a clear night, but in a letter Mr. J. Aitken, F.R.S., who has given very careful attention to the subject, demurs to the idea that the fog layer prevents further cooling. If I understand his meaning correctly the fog, or the upper part of it, radiates the heat instead of the surface, and the cooling goes on. It would add immensely to our information if we could find out what really happens when the sun shines on the fog layer. It may be taken as determined from meteorological observations that where fog is persistent throughout the day the temperature remains low, while the air of the neighbouring places free from fog gets warmed by the sun. Why the sun's heat does not dissipate the fog upon which it shines is one of the unsolved problems of this interesting subject.

Again, we can suggest a speculative explanation of the persistence of fog in London, though until it can be examined by observation it must remain only a speculation. The explanation is suggested by the character of early morning fogs that often occur in London. We find them even at 9 o'clock in the morning in October as white country fogs, particularly thick in or near the open spaces. But they probably have little vertical depth. The fog is carried in shallow layers of cold air. Over the top of it, probably, at that hour of the morning, is a layer of warmer smoky air that has been sent out from the London chimneys. This upper layer may take up some of the sun's heat and dissipate its influence upon the flood of cold fog-laden air that reaches up up to or a little above the house-tops. We are pushed, therefore, towards the inquiry whether the atmosphere of London has any special effect upon the heating power of sunshine. This is a question that can be easily answered from the report of the fog inquiry. The figures are given as a frontispiece to the final report where the results of the sunshine recorders at Westminster, Bunhill Row, and Kew are compared with those for the outside country. The recorders work by the burning of a card through the convergence of the sun's rays, so that they are just of the kind to give us the answer to the question we have put. The figures are eloquent enough. Bunhill Row loses 83 per cent. of the burning power of the

December sun, Westminster 61 per cent., Kew 15 per cent. The January figures tell a similar tale, so that we may be quite sure that if the sun has any substantial power of dissipating early morning fog, the smoke of the London atmosphere must seriously interfere with its effect.

However eloquent the figures may be, an actual comparison of the records is even more so. I have therefore had a diagram prepared, showing the daily records of sunshine at Bunhill Row, Westminster, and Cambridge for last December. They show a point which is not fully represented by the figures, namely that the sunshine that is measured is less strong in the smoky districts than elsewhere, and they afford very clear evidence of the interference with the sun's power of dissipating fog.

There are other points about London fog which await further investigation; for example, the peculiar manner in which the density varies from place to place, and the sudden local changes from light to darkness and back again. These are peculiar to town fogs, and must depend upon some processes which might, perhaps, be observed from a balloon above the fog, but at which, in the present state of our knowledge, we can only guess. Possibly they are connected with the general indraft of air towards London during fogs which was indicated both by Captain Carpenter and Mr. Lempfert, confirming the suggestion which had already been put forward by the Hon. Rollo Russell, but their connection with smoke is quite undetermined.

In so far, therefore, as anyone's action in regard to the smoke question may depend upon the effects of smoke on the frequency or intensity of fog, it would appear from such evidence as we possess that the abolition of coal smoke would cut off twenty per cent. of fogs altogether, that it would add most materially to the power of the sun to dissipate fogs and thus indirectly reduce their duration. The abolition of the dirt and the restoration of something like our natural heritage of daylight would be incidental advantages by no means unworthy of consideration.

CONFERENCE ON SMOKE ABATEMENT.

Wednesday, December 13th, 1905.

SUBJECT: "DOMESTIC SMOKE ABATEMENT."

ADDRESS

By SIR GEORGE LIVESEY, M.Inst.C.E., M.I.M.E.

TO induce an individual to change a long-fixed habit or practice is a very difficult matter, unless it can be shown to be decidedly to his interest and advantage. To change the habit or practice of the inhabitants of a great city can only be undertaken by enthusiasts, who must be gifted with exhaustless patience and perseverance, for at the best they cannot hope to see anything but a very gradual change. But there is hope for London; the abatement of its smoke has begun. To estimate the proportion of the smoke of London due to domestic fires is impossible. It is certainly very large and greatly in excess of that produced by factories, etc. On a still day even a few cottages will fill a country valley with smoke, as I once saw with astonishment; and I often see from a hillside overlooking the lower part of a town the great amount of smoke from a few hundreds of small houses. In fact, if domestic smoke could be abolished, that from factories would be found to be less than is commonly supposed, and would cause little trouble. Gaseous firing, the gas engine, and the dynamo are potent agents for the diminution of factory smoke.

I can only suppose that my connection with the supply of gas in London is the reason why I have been asked to occupy the honourable position of chairman at to-day's Conference, in order that the information bearing on smoke abatement possessed by the gas companies might be given, and possibly some indication of further steps in the direction of gaseous fuel that may be taken. If (and it is certainly a big *if*) a suitable

gaseous fuel, at a low price, could be substituted for the bituminous coal now used so largely, the trouble would be ended. The improvement that has taken place during the last twenty years, much more in the later than in the earlier ten years, is due to the substitution of gas for coal by the general adoption of gas cooking stoves by all classes, and particularly the wage-earners. The smoke from cooking is an old source of trouble, for the other day I found these quaint lines:—

> "Observe how the chimneys
> Do smoke all about;
> The cooks are providing
> For dinner no doubt."
>
> From *Poor Robin's Almanack* (1695).

The following figures will show how this source of smoke is being diminished. I have been obligingly furnished by my friends, Mr. Watson, the General Manager of the Gas Light Company, and Mr. Stanley Jones, Engineer of the Commercial Gas Company, with the number of cooking stoves, etc., so far as is known to them. I only give the statistics for the three Metropolitan companies, but all the suburban companies are working on the same lines. Within the last ten or twelve years, by the introduction of the penny-in-the-slot meter, almost the whole of the wage-earning classes of London have been supplied with gas, whereas previously not one in a hundred used gas, for which there were two reasons, the cost of fitting up their houses and the periodic collection of the gas accounts. The gas companies now fit up the houses and tenements, providing meter, cooking stove, pipes, fittings, and burners; all, including the gas, being paid for by the pennies put into the meter.

Cooking Stoves in use in the Districts of the Three Metropolitan Gas Companies.

	Ordinary Consumers.	Cooking Stoves.	Slot Meter Consumers.	Cooking Stoves.
The Gas Light	252,273	101,545 = 40 %	214,961	164,699 = 76 %
South Metropolitan	108,305	82,370 = 76 %	188,729	161,344 = 85 %
Commercial	25,000	9,000 = 36 %	45,000	28,450 = 63 %
Totals	385,578	192,915 = 50 %	448,690	354,493 = 79 %

	Total Consumers.	Total Cooking Stoves.
Ordinary	385,578	192,915 = 50 %
Slot Meter	448,690	354,493 = 79 %
Grand Total	834,268	547,408 = 65 %

These figures are an under-statement, being only those known to the gas companies as stoves let on hire or sold to consumers; but some consumers have purchased stoves of the makers. It will therefore be safe to say that of the 834,000 consumers supplied with gas by these three companies, about 70 per cent., or 584,000 use gas stoves for cooking. The only reason why it is not 100 per cent. in the case of the slot-meter consumers is that in a certain number of their habitations a cooker cannot be fixed, sometimes because there is no place for it and in other cases because the landlords will not permit it. One of the greatest and best of the philanthropic trusts for a long time refused permission to fix a stove in their buildings, and now that objection has been overcome it is found that in a large proportion of their tenements there is no place for the gas cooker, they having provided good ordinary ranges to burn solid fuel.

From the King's palace to the cottage or the small tenement of the workman, from the small room occupied by a single man or woman to the largest business and other establishments where hundreds are fed daily, gas is used for cooking. The demand for gas cookers is still maintained, the three companies supplying not less than 700 to 800 a week; and if the other companies in the immediate suburbs are included, the new cookers fixed in all London must average about 1,000 a week. Substitute coal for all this gas and what would be the condition of London?

But this result has been obtained by slow degrees. The first introducers of gas stoves were the late Mr. Sharp, of the Southampton Gas Company, I think in the forties, and shortly afterwards the late Mr. Goddard, of Ipswich, the father of the Member of Parliament for that borough. Prior to 1850 the cooking in my father's house was done by gas, but only by very slow degrees did it become general. For about thirty years, and in some places longer, the gas companies left the introduction of cooking stoves to the makers and to the consumers, who had to purchase them outright, with the result that comparatively few came into use. It is to the system of letting on hire at a quarterly rental to ordinary consumers and to the supply of stoves with the slot meters that the present position is due. I am afraid I cannot say that the question of smoke abatement has had anything whatever to do with it. The gas companies simply desired to increase their business, and the consumers found it advantageous to use gas for cooking; the necessary facilities were given and that is all. It will be no departure from truth to say that not a single gas cooking stove has been fixed with the object of preventing smoke; in fact, that worthy object has never been considered by the

parties, but, *hey, presto!* it has, so far as cooking is concerned, been accomplished.

There remains a more difficult task for the advocates of smoke abatement, on which, if they are to succeed, they must concentrate their attention. The domestic fire used for heating is the problem. It needs extreme care, suitable appliances and expert knowledge to burn bituminous coal in a steam boiler or factory furnace generally, without smoke. It is vain to expect such a combination in the case of the domestic fire, though it may be improved. The main hope, therefore, lies either in smokeless solid fuel or gaseous fuel of some kind. The only solid smokeless fuels at present available are anthracite and coke. The former is not burnt in the ordinary domestic grate, and although the latter can be so burnt it has not been extensively adopted, except in small houses, and not by any means generally. Coke, no doubt, is best when used in close stoves, and is very effective, and the same may be said of anthracite. Abroad, close stoves are common, but England will have none of them for the heating of sitting-rooms.

We have been too long used to the cheerful open fire (which, in addition to its cheerfulness, serves another most useful purpose, as a ventilator) to give it up without good reason. Constructed as our houses usually are, we have to depend for ventilation on the chimney. I have had a number of experiments made in eight rooms, which show that in ordinary dwelling-houses the chimney, when the fire is burning, will take away about five times the cubical contents of the room in an hour, in some cases slightly less, and in others considerably more, the range being from 7,400 cubic feet an hour in a cottage bedroom (cubic contents about 1,000 feet and a chimney 10 feet high) to 17,200 in that of an ordinary dwelling-house, in a sitting-room of 2,104 cubic feet contents. In this case the chimney is 45 feet high above the fireplace. The lowest ratio in the eight experiments was five times, and the highest about ten times the quantity of air equal to the cubical contents of the room in an hour, that is where a fire, in some cases a gas fire, was burning. In one room of the cottage where there was no fire there was no measureable draught up the chimney. The air in a room with the window shut is not so fresh in the summer as in the winter, owing to the absence of the fire to create a draught up the chimney. The great importance of a good draught up the chimney is therefore clear, and is a justification for the open fire against the closed stoves. Gas fires are often so placed as to partially block up the chimney and thus check the flow of air, which is

probably the reason why complaints are sometimes made against them. This, however, can be, and is, in many cases, avoided. The chief objection to gas for heating is that it is more costly than coal when the fire is required throughout the day. Therefore the inhabitants of our towns will not adopt gas generally, even to please the Smoke Abatement Society. Give them heating as efficient, as convenient, and as cheap as the coal fire, and they will in time (for the householder is very conservative) adopt gas generally. As to convenience and cleanliness in the house, gas has a great advantage over coal, which is one point in its favour. And for efficiency and ventilation it can hold its ground, but its price is the crucial point. It is, however, used more extensively than is generally supposed. The exact number of gas fires in use can only be estimated, because in the majority of cases they are purchased by the consumers. The South Metropolitan Company have 19,765 on hire, but this is no measure of the total. A canvass has been made in a number of streets, mostly of private houses, with the result that 38 per cent. of the ordinary consumers have gas fires in their houses, with an average of two fires to each house.

The following is the list of the places canvassed:—

Place.	Number of Houses Canvassed.	Number of Gas Fires.		Number of Incandescent Burners.		Number of Consumers using Cooking Stoves.
		Consumers.	Fires.	Consumers.	Burners.	
Kennington Park Road	93	27	46	77	355	71
Narbonne Avenue, S.W.	100	37	45	96	365	96
Burnt Ash Hill, S.E.	78	52	124	53	250	44
Stockwell Park Road	68	22	37	48	235	57
Camberwell Grove	63	24	42	53	342	41
Wickham Road, Brockley	52	38	100	38	271	34
Louisville Road, Upper Tooting ...	123	41	88	115	571	106
Norwood Road	98	39	71	83	420	78
New Cross Road	60	14	35	54	253	42
Wrottesley Road, Plumstead ...	72	27	43	62	268	63
Maryon Road, Woolwich	83	25	42	74	457	76
Lee Road	74	30	94	48	189	36
Trinity Street, Southwark	33	3	3	28	133	17
	997	379	770	829	4,109	761
		38%	Average 2 to each	83%	Average 5 to each	76%

The great desideratum for smoke abatement is cheap gaseous fuel. Fortunately illuminating gas, thanks to the Welsbach mantle, is no longer necessary, heating power being the only requirement. To use gas with a

luminous flame burner is now nothing less than unjustifiable extravagance. As shown in the above table over 80 per cent. of the consumers use the mantle, and in a short time it is hoped that it will be as difficult in England as it is in Germany to find a flat flame burner in use.

This being the position, there is no real obstacle to the supply of one quality of gas for all purposes. Prior to the introduction of the mantle it was held that if fuel gas were wanted it would have to be supplied in separate mains, and this would have been impracticable. There is not room in the roadways for another complete set of large gas mains. Now, however, an eight-candle gas would answer all purposes. An entirely non-luminous gas would do but that there are passages and cellars and other out-of-the-way places where a small light is necessary, and this can be better obtained by an ordinary burner than by the use of a mantle.

There are, however, two difficulties in the way. In London the County Council have put every possible obstacle in the way of all the gas companies' efforts to obtain Parliamentary sanction to reduce illuminating power, and in the meantime the production of cheap gas suitable for all purposes is delayed. This struggle began in 1900 and is still going on; a notable advance having recently been made in the shape of a just method of testing gas. For nearly forty years have the companies been subjected to a system of testing that entailed enormous expense and constant worrying anxiety, with no advantage to the public. This great waste of the money of the consumers and ratepayers is due to the mistaken idea of the London County Council that every proposal of the gas companies must be at variance with the public interest. The gas companies have no monopoly now, but are subject to fierce competition. If they do not supply the article the consumers want they lose business. The restrictions imposed by Parliament (when they had an absolute monopoly and gas was the only practicable artificial light, the choice being between ordinary tallow candles, or oil at from 5s. to 7s. a gallon) are now not only useless but mischievous, because they stand in the way of the production of cheap gaseous fuel, which I believe to be the great desideratum for the prevention of smoke.

The second difficulty is that we have not yet found the gaseous fuel suitable for the purpose, which can only come by slow degrees. We want freedom to work in that direction. The just method of testing mentioned above, to come into force in the New Year, will give us a certain measure of freedom to start towards the goal of a cheap fuel gas.

It is in these means that, in my opinion, lies the best hope of success in the abolition of smoke. It can come only by providing the public with

means to supply their needs for heat and light that will suit them better than those at present available. The domestic fire is the point to attack, and this will not be given up for sentimental reasons. No householder will give up his coal fire simply to prevent a smoky atmosphere, but if an efficient and cheap substitute can be found then a gradual change will be made. Legislation to control the householder in this matter is futile, and I hope The Royal Sanitary Institute and the Smoke Abatement Society will not follow the Socialists in the belief that everything can be done by Acts of Parliament. As much freedom as possible is what we want if we are to progress; but put not trust in legislation, which means restriction. The boy who said that pins had saved many lives explained that it was by people *not* swallowing them, and in like manner Parliament does a great deal of good by *not* passing many of the Acts introduced every Session, and as many of those now on the Statute Book are productive of harm, Parliament might be much worse employed than in repealing those that are unnecessary and mischievous.

THE ABATEMENT OF SMOKE FROM PRIVATE HOUSES.

By H. A. DES VŒUX, M.D.

THE five million inhabitants of London are each and all adversely affected by the smoke which thickens our atmosphere from one year's end to another; and what then is the reason why so few can be induced to join the smoke abatement crusade when all would be the gainers thereby? I think it is this. For more than five hundred years coal has been brought to London for consumption in fires, and for all that length of time smoke has been added to the atmosphere; and it was not imagined that the amount of smoke could be diminished either from factory or domestic chimneys, and no other satisfactory method of heating was tried or perhaps known. The impression was that heat must be produced; coal is the only source of our heat; smoke is a necessary result of coal-burning.

It is my duty to point out some means by which smoke from private houses can be avoided. In the majority of English houses, the cooking is still done by coal in an open fire, and sitting-rooms and bedrooms are heated in a similar manner; while most people would consider it an act of tyranny if they had to change their ways, which, if they are dirty and inefficient, do not seem to them very costly.

To see what could be done to improve coal fires, the Coal Smoke Abatement Society (to whom every assistance was given by His Majesty's Office of Works) carried out two series of tests, see *The Lancet* of May 10th, 1902, and February 20th, 1904. A further and much larger series has just been carried out in the new Government offices in Great George Street, under the superintendence of Sir Henry Tanner (principal architect to H.M. Office of Works) in conjunction with a small sub-committee of the Coal Smoke Abatement Society. Broadly speaking, it may be said that there is no such thing as a smokeless open coal-fire, but, under efficient management, there are vast differences in the smokiness of fires, those which give the greatest amount of heat for the least amount of coal

consumed emit the smallest amount of smoke, and therefore efficient coal fires are to a certain extent smoke abaters.

If you want your atmosphere cleared of smoke, you will have to give up the use of crude bituminous coal and to use some of its products, such as gas or electricity, or some smokeless fuel. Our cooks have already found out that a gas-kitchener is essential, and have discovered its advantages. But, unfortunately, smoke is still emitted from the kitchen-chimney, for in all moderately large houses it is necessary to have a hot-water system as well, and in most houses the old coal-range is lighted for this purpose. Eight years ago I installed a coke-boiler, which has given a magnificent hot-water supply throughout the house at a temperature of about 170° F., and the supply has been so plentiful that I have been enabled to put on three hot-water radiators in passages. The cost of this system is from 1s. 3d. to 2s. a week, depending mostly on the price of coke. If a gas-cooker and a coke-boiler were installed in all the houses in London, the greater part of the smoke from private houses would be prevented. When we come to the sitting- and bed-rooms our problem becomes easier: I myself have a gas log fire in my consulting-room, an anthracite closed stove in my dining-room, an open coal fire (the Florence grate) in my morning-room, and gas fires in my bed-rooms. The objections made to gas fires are the reputed drying of the atmosphere, the sentimental points that they are not so pleasant to look upon, and that they cannot be poked! The last is trivial, but the second has some force, on account of the pleasant sensation from the sight of a bright-burning coal fire. The first objection is a real one, if true. I find that with a gas-fire in a room with no ventilation, a peculiar sensation of dryness is produced, but that it is readily removed by opening the window an inch or two. This is therefore an advantage, and not a draw-back; and there is certainly less draught in a room with a gas fire than in one with a coal fire.

The Lancet's article of November 26th, 1893, on heating and cooking by gas, unhesitatingly recommended gas for both purposes. It takes for granted that a gas-fire dries a room more than a coal-fire, and states that this can easily be altered by the use of a bowl of water. But the drying of the atmosphere was not proved by analysis, and it has since been denied by competent authorities. I think that it is a subject which the gas companies might profitably take in hand. Whenever a complaint is made as to fumes or dryness from a gas-fire, an analysis should be made of the atmosphere of the room and the gases in the

chimney, and I feel no doubt that we should soon be at the bottom of this frequent cause of disparagement of gas-fires. With regard to cost, in my own house cooking by gas is slightly (ten per cent. or less) dearer than by coal; I append some figures showing the enormous increase in the employment of gas-stoves during the last ten years; since small consumers and poorer people are using them more and more. A lady writes to me that she often goes to bed without food, rather than go to the exertion of lighting her coal-fire. On my advice she installed a penny-in-the-slot gas stove, and besides the comfort, finds it much cheaper than coal, costing on an average 1s. 2d. a week, against 1s. 8d. for coals. Messrs. Lyons, the well-known restaurateurs, spend £10,000 per annum on gas for cooking.

Electric heaters, anthracite-stoves open or closed, coke and other smokeless fuels, are also available for sitting-rooms. The first are becoming more frequent since the electric companies reduced their prices for current; emitting no smoke and no fumes, they are bright and cheery, requiring only a switch to turn them on and off, but they do not help in the ventilation.

Anthracite open fires are absolutely smokeless, give a great heat, and are efficient ventilators, but the fire is not so bright or quite so lively as a bituminous coal-fire, and it is somewhat difficult to light. I believe that they are not costly, although the coal is dearer.

Closed stoves, mostly French and German burning anthracite, are more and more used; they are alight night and day, need only be stoked once in twenty-four hours; are very economical (mine only costs 3d. for twenty-four hours), but they are cheerless things, and in my opinion are best fitted for dining-rooms, which are only used at certain intervals of the day, or in halls or passages, where they are excellent.

Of oil-stoves I need say little, they are cheap and economical, useful in halls and passages, but not quite suitable for sitting-rooms and bed-rooms.

Hot water and steam systems through a house are not common in England, but I think that by reason of their economy and labour-saving advantages they will be more employed.

In proving that the problem of abating a smoky atmosphere from house-warming is not a hopeless one, I have no wish to push gas as against electricity, anthracite coal or coke. Smokeless cooking will rid us of 600,000 dirty chimneys, and the effect will be enormous. Smokeless heating will follow in due time, and for those who insist on having an open coal-fire, it should be a *sine qua non* that only those grates are

allowed which have already been tested by some public authority as to their efficiency.

Increase of Gas Cookers bought or hired from Gas Companies in 10 years, 1895–1904.

Metropolis and Suburbs.		
Using Penny-in-Slot meters	365,000	535,000
„ Ordinary meters	170,000	
Twenty Provincial Towns.		
Using Penny in Slot meters	135,000	315,000
„ Ordinary meters	180,000	
Total Increase in 10 years		850,000

Most of the huge installations of cooking ranges for clubs, restaurants, hospitals, etc., are not bought through gas companies.

Increase of Heating Stoves bought or hired from Gas Companies, 10 years, 1895–1904.

Metropolis and Suburbs	120,000
Provincial Towns	50,000
	170,000

It is probable that a much larger number of heating stoves are bought from makers or ironmongers than from gas companies.

COKE (CHARRED COAL) AS DOMESTIC FUEL.

By SIR CHARLES COOKSON, C.B., K.C.M.G.

I HERE give my experience of the use of coke as the only fuel in all the grates in my own house. One grate is a Garland of the most approved modern pattern; three are of the ordinary 18th or 19th century make, two are large open grates belonging to the old sitting-rooms of the original mansion, and the seventh is an ordinary kitchen range with hot plates and boiler. For roasting, a separate movable gas stove has been found necessary. No bituminous coal but only the coke sold by the Gas Light and Coke Company has been used for five years, and in no case is any special apparatus or grate required.

Coming to live in London from sunny Egypt, and disgusted at the contrast of the atmosphere, I determined not to contribute to the nuisance, and to burn only smokeless fuel. I tried anthracite for a time, but soon took to coke on account of its greater cheapness as well as its far higher power of radiating heat. The initial difficulty of both these smokeless fuels was in lighting them; but I easily overcame this by putting under the grate an iron pipe, connected with the gas service of the house and perforated by air-holes at the side, so that the gas when lit reaches the coke laid on the lower bars of the grate. The flow of gas is controlled by a Bunsen burner, higher up in the pipe. I find that the gas takes about ten minutes to ignite the coke, and that the average consumption in that time is something less than six feet. The fire is kept up for the rest of the day by coke alone. This is much the best method of igniting, but if the fire is lit in the ordinary fashion with common coal, after that has once become heated there is no difficulty in using coke only for the rest of the day, and the smoke is reduced to a minimum. I believe I have satisfactorily solved the question of the abolition of that large part of the smoke nuisance which arises from the domestic chimney. Incidental advantages of the method are :—

(*a*) At the present price of broken coke, 12s. for 12 cwts., its cost is nearly half that of household coal, and is still cheaper in comparison with inferior coal which the poor are obliged to buy in small quantities. Wood or other kindling material costs about 5d. or 6d. a week for every fire; but the consumption of six feet of gas per diem at the current price costs no more than ½d. per week.

(*b*) The fire can be lit at any time without trouble, and the gas flame gives an immediate heat up to the moment that the coke is ignited.

(*c*) Coke, the lumps of which never cake, very soon gives a glowing mass of fuel, and radiates greater heat than any other house-heating combustible.

(*d*) Absence of smoke from the room causes cleanliness in furniture, upholstery and wearing apparel, and saves quite 50 per cent. in cleaning. Any fine dust from the ash of the coke is not dirty; there is no damage like that from soot to furniture or books, and no expense and trouble from sweeping chimneys.

Coke is far cheaper than anthracite, and radiates a much greater heat. It is much more economical than gas, electricity, and special smoke-preventing apparatus, and requires no alteration in any grate now in use. It further satisfies the preference of the British public for the cheerful aspect of a fire in the open grate. I have no hesitation in saying that there is no foundation whatever for the complaint that it gives out unhealthy fumes. Of course, where there is not sufficient draught through the fire some of the gases which are imperfectly consumed are liable to escape into the room. But though I have seen coke used in very small grates in very small rooms, I have never known any complaints on this head; and wherever this difficulty exists there are obvious means of curing it by producing an artificial draught. On this important point I hope to be supported by testimony from those who have successfully burnt coke in their own houses.

A real objection is that nearly all our coke is at present a by-product of gas-retorts, and its quantity is insufficient to meet such a demand in London alone. The only remedy is to produce a "*charred coal*," which, after utilising a part only of its valuable volatile by-products, could still be sold at a lower price than that of bituminous coal, as has been done in Germany and elsewhere. Charred coal is produced by a newly invented and more economical pattern of coking-oven in Germany, for 8 marks per 1,000 kils. (equal to 1 ton); and there is no doubt that its quality could be improved. If manufactured in England, it could be delivered in

London at a proportionately small cost. To those who still prefer the look of a lively coal fire with its lambent flames, I would recommend a trial of the effect of a "ship's log" on the top of a glowing coke fire.

The plan I advocate in this paper, if universally adopted, would save London alone £5,000,000 a year, besides removing the curse of smoke.

It was only subsequent to the experiences detailed in this paper that I became acquainted with valuable suggestions in the same sense in connexion with a great scheme for "The Heat, Light, and Power Requirements of London," in *Page's Magazine* for April, 1905, and elsewhere, by the eminent engineer, Mr. B. H. Thwaite. He anticipated much of the contents of this paper.

A RECORD OF THE WORK OF THE LEEDS SMOKE ABATEMENT SOCIETY.

By Prof. J. B. COHEN, Ph.D., B.Sc,

The University, Leeds.

THE Society was formed in 1890, (1) To determine the nature and extent of atmospheric impurities arising from coal smoke, (2) To consider the question of coal consumption in boilers, furnaces, and domestic fire-places, (3) To examine the efficiency of the present system for controlling the emission of smoke.

A calculation of the amount of soot in the air of Leeds, as half per cent. on all the coal burnt, gives much too low a figure for *domestic* coal, which yielded by experiment an average of 5 per cent. of soot with the better qualities of coal. But at half per cent., the daily consumption of 4,000 tons in Leeds means twenty tons of soot, and a similar figure was obtained by aspirating large quantities of air through a weighed plug of cotton wool. Most of the soot is blown away, but we find that about half a ton falls in Leeds each day. This figure was obtained in January, 1892, when a square yard of snow was removed daily from the parish churchyard, the snow melted, and the soot estimated. Most of the daily sootfall is washed away in time, but as it contains about 15 per cent. of a sticky oil by means of which it adheres and quickly discolours brick and stone work, not to speak of fabrics, furniture and clothes, at least 25 lbs. per day sticks and is not removed by rain. This was determined by means of glass plates exposed at some distance from chimneys, and examined every few weeks. Those exposed at about nine miles from Leeds remained almost clean. In addition to the sulphurous acid and soot, the loss of light was also estimated daily at different stations in 1895–96, and showed a considerable difference in the town. These examinations convinced us of the substantial nature of the nuisance.

The means of diminishing the evil by the better consumption of fuel

had already been attacked, as regards boiler-furnaces, by Mr. Herbert Fletcher of Bolton, for the Manchester Smoke Abatement Society, and a valuable report in 1896 on his tests, with those of other observers, concludes that "a manufacturing district might be free from manufacturing smoke, at least from steam boilers."

The evil of smoke might be met if more attention were paid to the use of gas-fires. In numerous experiments as to their products of combustion and heating effect, with a proper chimney-draught, I have never found any emission of noxious gases into a room, nor any carbonic oxide even in the flue-gases. The heating effect when burning about 22 cubic feet of gas per hour, is greater than that of 3 lbs. of coal per hour in an ordinary fire-grate, but the cost of the gas is almost double. One defect of gas-fires that ought to be easily remedied, is that, unlike a coal fire-place, they produce very little ventilation.

As to the third item, the efficiency of the method of control, the Leeds by-law limits the duration of black smoke from factory chimneys to five minutes in the hour. Manchester only allows one minute, and I believe that Nottingham, in the interest of the lace-industry, only permits five minutes in the morning of each day. In our own inspection for three weeks at Leeds, out of 79 boiler chimneys 51 emitted black, opaque smoke for over ten minutes in the hour. Yet the convictions for smoke nuisance are ludicrously few: in one year, there was only one, and the average is six per annum, with a fine of 10s. each.

The Society soon decided as to the best mode of treating the problem, on the lines of an annual report of the former chief alkali inspector, Mr. A. E. Fletcher. "The complaints that are brought against the emission of black smoke from factory chimneys are numerous, but too intermittent and desultory to bring about much diminution of the evil. The Alkali Act gives no power to control common coal smoke, yet at two points it comes so near it, that the question has often received my close attention. . . . . Masters will not take the trouble to alter their furnaces nor will the men alter their method of stoking their fires unless they are compelled. The numberless alterations made in the construction and conduct of chemical works during the last twenty years would never have been carried out, but for the pressure brought on the manufacturers by means of the Alkali Act."

Our Society therefore resolved to press for an extension of the Alkali Act bringing the chimneys of all works under the same kind of control, to memorialize the Local Government Board for the appointment of

Government inspectors, and with this object to join forces with the Manchester Smoke Abatement League and the Sheffield Smoke Abatement Society. The memorial was very largely signed by all the principal Sanitary, Medical, Architectural and Botanical Societies in Lancashire, Yorkshire and elsewhere, and resolutions in favour of it were received from Trades Councils and other representative bodies; but it was never presented, as the Local Government Board declined to receive either deputation or memorial. Nevertheless, we in the North are still convinced that these are the lines which are most conducive to the effective solution of the smoke problem.

THE ACIDS OF SMOKE.

By SAMUEL RIDEAL, D.Sc.Lond., F.I.C.

(F.R.SAN.I.)

IN discussions on the smoke-question the evil effects arising from the acid gases, which are associated with all kinds of coal-smoke, are frequently overlooked. Penalties can only be recovered when black smoke is emitted; but as the colour is only a measure of the amount of smoke escaping, it does not give even approximately the amount of associated acids. It is evident that the Legislature has regarded the nuisance as one which only affected the amount of light to which the inhabitants of towns were entitled, and the chief defect in working the Act was due to vagueness in defining what this phrase "black smoke" means. For many years past it has been thought desirable to eliminate the word *black* from the definition in the Act and make it applicable to smoke, irrespective of colour, as it is obvious that although the light obscured may sometimes be less, the total effect after the smoke is dissipated must depend upon the proportion of unconsumed coal which passes into the air. Such an extension would, however, leave untouched the question as to the injurious effect of acids produced in the ordinary combustion of coal, and even if mechanical stokers, and other means of preventing the issue of unconsumed particles into the air, are used, the quantity of sulphur-acids produced will remain the same.

During the past fifteen years I have had to examine the atmospheres of town and country with a view to determining the amounts of sulphurous and sulphuric acids, and have found that these two acids always increase in foggy weather and are normally present to a greater extent in the air of towns than in rural districts. It is easy to calculate from the quantity of volatile sulphur in coal, the amount of sulphur-acids produced in a district, in a given time, when the coal-consumption is known. In London, about sixteen million tons of coal are used per annum directly for heating purposes, and the sulphur-content of this coal may range from 1 to 2 per cent., giving an annual production of half-a-million to a million tons of sulphuric acid which is diffused in the air.

Condensation and rain remove the acid gases from the air, as they are readily soluble in water. Fountains, like those at Trafalgar Square, act as scrubbers of the air and should be encouraged by municipal authorities, so as to diminish the quantity of soluble acid constituents in the air. The analysis of rain-water collected in the neighbourhood of towns and its marked action upon galvanised iron and other easily attacked metals, on exposed fabrics, and on building stones and mortar, prove the prevalence and injurious effect of the acid impurities. It has been shown by many analyses that the surface of buildings and outside sculptures becomes converted into a crust of sulphates, and along with the corrosion there is a roughening on which carbon settles, making the well-known black streaks or stains.

Dolomite limestone (*e.g.*, Westminster Palace) is the stone which appears to be most affected, owing to the solubility of the magnesium sulphate formed. The Oolitic limestones (*e.g.*, St. Paul's), which contain little or no magnesium carbonate, are far more durable in acid town-air. A baryta-wash seems to be one of the best antidotes.

From the results of a large number of analyses of the air of London, Manchester and Liverpool, a report of the Air Analysis Committee of Manchester, in conjunction with the Royal Horticultural Society, concluded that:—

1. In clear breezy weather the amount of sulphurous acid is less than 1 milligramme (·015 grain) per 100 cubic feet of air.

2. In anticyclonic periods it rises very considerably, and in times of fog, 34 to 50 milligrammes (0·51 to 0·77 grains) have been recorded for the worst districts of Manchester and London respectively.

3. Wherever an open space or a less densely populated area occurs, there is a marked diminution in the amount of impurities in the air.

4. Increase in the amount of sulphurous acid is accompanied by at least as large an increase in the amount of organic impurities in the air.

5. Smoke, promoting as it does the formation of fog, and preventing diffusion into the upper stratum of the air, is the principal cause of the impure state of the atmosphere in large towns.

In 1891–2 there was an extended investigation of the subject, in which I was engaged with others, and the following table gives a summary of the results, with some additional ones since obtained:—

Sulphur in grains per 100 *cubic feet.*

Locality.	Averages, Nov.—April.	Mean for the rest of the Year.	Maximum.	Minimum.
MANCHESTER. 1891–92.				
Owens College	·039	·017		
Hulme	·048	·024		
Town Hall	·057	·017		
Ordsall	·058	·026	·198 December	·003 October
Mean of the four localities	·050	·021		
LONDON. 1891–92.				
St. George's Hospital (Rideal)	·050	......	·120 December	·004 December
University College, Gower Street	·081 November	......	·244 December	·029 November
LONDON. 1903.				
Victoria St. (Rideal), March	·009	......	·012	·004
Old Kent Road, November	·0162	......	·025	·009
„ „ „ December	·0165	......	·022	·008
LILLE, 1884 (Ladureau)	·100	......	·120	·080
Country air:				
Hanover, 1900 (H. Ost)	......	·012 whole year		
Elstead, Surrey (Rideal), Dec., 1903	......	·001		

The following details from the results at Gower Street show the difference caused by atmospheric conditions in short intervals of time:—

Sulphur in grains per 100 *cubic feet.*

Dull Days.			*Foggy Days.*		
Nov. 5th.	Dull	·034	Nov. 24th.	Slight fog	·064
„ 6th.	„	·029	„ 30th.	Dark and very foggy	·107
„ 10th.	„	·042	Dec. 21st.	Yellow fog	·128
„ 13th.	„	·053	„ 22nd.	Dense black fog	·244
„ 17th.	Slight fog	·051	„ 23rd.	Yellow fog	·081
„ 20th.	Dull	·042	„ 24th.	Thick yellow fog	·128

The detrimental action of urban fog on plants is due not so much to sulphur-compounds, as to the deficiency of light, the cold dampness and the deposit of tarry substances, soot and dust. In a series of experiments on growing plants made in 1903, I found that a proportion of pure diluted sulphurous acid gas many times greater than that present in a thick yellow fog, was tolerated, the effect being only comparable to that of a change of a few degrees in temperature or of a moderate reduction of light.

Coal-soot and dust are also found to concentrate the sulphur compounds; for instance, samples of soot in London contained 4·6, in

Manchester 4·3, and in Glasgow 7·9 per cent. of SO_3, equal to 1·84, 1·72 and 3·16 per cent. of sulphur respectively. From experiments at Leeds and Manchester it was estimated that the soot which fell in 24 hours per square mile, was in the former place 250lbs., and in the latter about double that quantity during fog. The dust from 20 square yards of glass roofs at Kew and Chelsea, contained nearly 5 per cent. of SO_3, equal to 2 per cent. of sulphur. A concentration also occurs from rain and snow. These, in Manchester, were found to contain, on 22 days between November and August, an average of 1·46 grains SO_3 (=0·58 S) per gallon, with a minimum of 0·18 and a maximum of 4·94. At Lille the rain-water contained sulphur compounds corresponding to 1·54 grains per gallon of SO_3, equal to 0·62 grains of sulphur.

As to the amount of sulphur sent into the atmosphere as acid gases every day in London by the three chief combustibles, I have calculated it from Board of Trade returns of the average quantities used, to be approximately as follows:—

	Coal.	Gas.	Mineral Oils.
Pounds of sulphur given daily in burning ...	981,792	893	743
Ratio to mineral oils as unity	1,321	1·2	1

The sulphur arising from the burning of coal is, therefore, 1,100 times that given by the combustion of gas.

Cohen and Hefford found that the distribution of the sulphur in the products of combustion of two kinds of coal was as follows in percentages of the total sulphur contained in the coal:

	A.	B.
Passing out as sulphur gases	71·78	60·
Absorbed in the soot and mainly escaping	14·51	11·88
Left behind in the ash	13·71	28·12

Mineral oils, as shown above, yield nearly the same quantity of sulphur as gas. The naphtha burnt about the streets and markets is either a distillate from coal-tar, or from petroleum; the latter may contain as much as 0·5 per cent. of sulphur (308 grains per gallon), and the former from 0·27 to 0·94 per cent. (166 to 579 grains per gallon). The refined product sold commonly as "paraffin oil" varies very much in sulphur contents, from 0·013 to 0·274 per cent.; I have found London shop-

samples at 8d. per gallon to contain 0·021 per cent., and at 10d. 0·045 per cent. (12·9 and 27·7 grains of sulphur per gallon respectively). We may conclude that hydro-carbon oils, when used for heating, contribute about the same small quantity of sulphur as gas does.

On the subject of the tarnishing of bright metallic surfaces, I found by experiments in 1903 with silver-foil, tin-plate, picture wire, curtain chains, "white metal," and electro spoons, that such articles were affected far more rapidly and deeply by the outside London atmosphere than by the air of rooms in which gas is burnt. This may be explained by the fact that the small quantities of sulphurous and sulphuric acids from the combustion of gas do not cause blackening on silver and many other metals, while sulphuretted hydrogen (which is removed from coal-gas) at once occasions it. We have seen that soot contains sulphur-compounds; Cohen and Hefford found that solid particles of soot influenced the discoloration of silver, and that when the air was filtered through cotton-wool the effect was greatly reduced. They showed also that clarified flue-gases from coal-fires blackened lead-paper, and inferred the presence of sulphuretted hydrogen.

In 1898, 35 million tons of coal were burnt per annum for domestic heating purposes out of 157 million tons of total consumption, and consequently there was no legislative control as to the smoke or acids produced from nearly one fourth of the total; five years later, the domestic consumption had fallen to 32 million tons, whilst the total consumption had risen to 167 millions, thus showing the modern tendency to replace domestic coal-consumption by improved methods of heating.

The substitution of coke for coal is only a partial remedy for the nuisance occasioned by the evolution of sulphur-acids, since the gas industry is not restricted in the sulphur-content of the coke produced.

The sulphur in coke varies enormously, and may equal or even exceed the amount in the original coal, and as in the combustion of coke no smoke is produced, the acid gases pass out unnoticed and undetected into the air. Possibly, being thus free from black, sooty and oily particles, the gases are more diffusible, quickly become dissipated into the greater volume of air, and when condensed by rain, or by contact with cold surfaces, are consequently more dilute and less harmful than the corresponding amount of acid produced from coal-consumption. It seems worth while for gas-engineers to turn their attention to this problem, as elimination of volatile sulphur from coke would considerably enhance the value of this commodity and would remove the chief objection to its extended use. Within recent years the question of the removal of sulphur-

clauses from Coal-gas Acts has been keenly debated in Parliament, notwithstanding the fact that the total amount of sulphur in coal-gas is diminished in the first place by the amount of sulphur retained in the coke, and in the second place by the universal and compulsory absorption of the sulphuretted hydrogen in the crude gas. The total amount of sulphur removed in this way from coal-gas is enormous, and makes the residual sulphur in gas, amounting to about 40 grains per 100 cubic feet, insignificant in comparison with the amount evolved in burning coke or coal, so that the relaxation of the sulphur-clauses, by reducing the cost of gas-purification and thus extending the use of gas for heating purposes, will produce the anomalous result of diminishing the sulphur-content of the atmosphere.

From experiments in 1902, and later with Mr. Hehner on a more extended scale given in evidence before a Board of Trade Committee, I found that burning coal-gas in a room does not increase the sulphur-content of the air to that reached in foggy weather in the outside air, because the water produced in the burning of the gas is far more than sufficient to absorb the sulphur-oxides, and this water condenses them on the ceilings and other basic materials present, where they become permanently fixed. A good whitewashed ceiling can thus act as an acid scrubber for many years in an ordinary gas lit room without renewal. But gas-stoves used for heating should always have a chimney, and in that case, since 95 per cent. of the sulphur is removed from the gas by purification, the sulphur-acids emitted into the air will be only a fraction of those emitted from an equivalent of burning coal.

Under the Alkali Works Act, the Legislature has already dealt with the serious pollution of air by acid gases emitted from works, and, in my opinion, these Acts ought to be extended so as to include the gases emitted from all works using coal and coke of a high sulphur-content for steam-raising purposes, without the absorption of these acids. This opinion has been held previously: in 1892 Mr. A. E. Fletcher, the then Chief Inspector under the Alkali Works Act, proposed "an Act for the Control of Noxious Gases," to be applied generally. He suggested as a definition: "a gas which is complained of, or which is notoriously a cause of complaint, or which in the opinion of the Inspector is liable to cause complaint," and thought that "the term 'Alkali Act' should no longer be used,—'*Acid* Act' would be more appropriate." Another definition proposed was "a gas which did appreciable harm to health or property."

THE DISTRIBUTION OF PRODUCER GAS AS A MEANS OF ALLEVIATING THE SMOKE NUISANCE.

By A. S. E. ACKERMANN, B.Sc.Lond., A.C.G.I., A.M.Inst.C.E.

(M.R.SAN.I.)

ANY scheme for alleviating, if not entirely removing, the smoke nuisance must necessarily be very costly in the case of London, on account of its vast size. For example, even so small a cost as one shilling per house amounts to £30,000, as there are some 600,000 houses in London, and this would go but a *very* little way towards the cost of a scheme, which, to be a complete success, must *ultimately* deal with every house, for in London the *domestic* forms 70 per cent. of the total smoke,* though one frequently hears it said that the former is of little account. We must not forget, however, what an extremely costly thing fog is to London, and how far-reaching are its evil effects. The Hon. Rollo Russell has estimated the total cost of fogs in London as over £5,000,000 per annum.† As even *one year's* cost would provide capital enough for a very large scheme, I argue that a successful (even if very costly) scheme would pay.

Dr. W. N. Shaw, in his paper just quoted, gives the following averages during the twenty years, 1881 to 1900:—

Percentage of possible duration of sunshine.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
London :—	10	15	23	31	38	36	38	39	34	24	14	9
Average for the Southern District of England :—	21	28	38	42	46	43	46	47	44	37	24	21

In Nov., Dec., Jan., and Feb. London gets *only half the sunshine that Southern England gets*, or only about 12 per cent. of the *possible* amount.

* Dr. W. N. Shaw, R. San. Inst. Congress at Manchester, 1902.
† "Smoke in relation to Fogs in London," The Smoke Abatement Society.

During May to August, when less house coal is burnt, London sunshine amounts to 84 per cent. of that in Southern England, or 37·8 per cent. of the possible. This shows a loss, due to the excess of winter smoke over summer smoke, of 34 per cent.

My proposal is that producer gas should be distributed to houses for warming and cooking and to factories for industrial purposes. This gas is made from the cheapest coal at a cost of 3½d. per 1,000 c. ft., and has a calorific value of about one quarter that of ordinary illuminating gas. 1s. 2d. worth of producer gas is equivalent to 1,000 c. ft. of ordinary gas costing 3s. The South Staffordshire Mond Gas Co. (cap. £1,000,000), having power over 123 square miles, now have some 14 miles of producer gas mains laid, and though they started to deliver gas only six months ago, the output is already 12 million c. ft. per day from the generating station at Dudley Port. This gas, however, is all used for industrial purposes, so will not decrease *domestic* smoke. The Act of Parliament under which the Company was formed does not allow them to distribute gas "for use in private dwelling houses." The price varies from 2d. to 4d. per 1,000 c. ft., or say 1s. for the heat equivalent of 1,000 c. ft. of ordinary gas, which in South Staffordshire costs 2s. 5d. per 1,000 c. ft. The minimum quantity which the Company may supply to any one customer is one million c. ft. per year, and the maximum price they may charge is 4d. per 1,000 c. ft.

Producer gas is suitable for practically all purposes for which ordinary gas can be used, except that it will *not* do for illuminating, as its flame is non-luminous and its calorific value is too low for it to be used with a mantle. The only objection that has been raised against it is that it contains about 20 per cent. of the very poisonous carbonic monoxide, but it is easy to reduce this amount. The South Staffordshire Co.'s Act does not allow more than 14 per cent. (and the gas has to have "a distinct, readily perceptible smell"), while ordinary illuminating gas, which is often enriched with water-gas, sometimes contains 12 per cent. of CO, so that the difference on that point is very small.

When I first suggested the distribution of producer gas for the purposes named some three years ago, I was not aware that it had been used for cooking and warming, though of course natural gas (which has a much higher calorific value) has been so distributed and used in America for years with signal success. I learned that the Gloucester County Asylum has used producer gas for cooking during the last twenty-two years; and that the Walthamstow Isolation Hospital has used it during the last five years for driving gas-engines, for warming the blocks of buildings, the hot

water supply, and for the whole of the cooking. The latter in December, 1903, was for 80 persons, but the same plant could easily serve 200. The cooking apparatus is arranged against two of the walls, and over it there are two wrought iron hoods which stand out 4 ft. 6 in. from the walls, and are placed 6 ft. above the floor-level. One of these was provided with an electric fan for drawing off the fumes, but very often it was found not necessary to use this. There was a slight smell of burning sulphur on entering the kitchen, and but for this it would have been impossible to tell that anything but ordinary gas was in use. The whole of the plant had, when I inspected it, been in use for two years and eight months. There had been no renewals, and they had had no trouble whatever. No headaches, no accidents. The stoves, etc., appeared exactly the same as any ordinary gas-stoves, except that the jets were slightly larger.

Producer gas is also used for cooking at the works of the following firms:—Messrs. Ashmore, Benson, Pease & Co., Ltd., Stockton-on-Tees; Messrs. Brunner, Mond & Co., Ltd., Winnington; and The Co-operative Wholesale Society, Irlam.

One very important point, as it would greatly reduce the cost of introducing producer gas warming, is that the existing open fire grates could be used without alteration, simply by the addition of a multiple Bunsen burner and hollow asbestos balls such as are used in gas-stoves using ordinary gas. This would *not* be the most economical way of using the gas, but would probably be sufficiently so in the case of most existing grates, while new houses could be fitted with efficient gas-stoves. In either case we should have the advantage (sanitary and sentimental) of an open fire, and it is hardly necessary to point out that properly designed and fitted gas-stoves are quite as wholesome as coal-fires. Unfortunately, there are many gas-stoves on the market which are poorly designed and far from efficient, and which when fixed either have no chimney at all, or a very unsatisfactory one. It is such stoves and statements which gave gas a bad name for warming some years ago and have done much harm by retarding its use, though it must be admitted that with gas at 3s. per 1,000 cubic feet, the cost is too much where *constant* fires are wanted.

The advantages of gas warming and cooking as compared with coal are:—1. Greater convenience. 2. Cleanliness. 3. Labour saving. 4. Economy (especially if producer gas be used).

Under these four headings we have:—

1. The fire is started in a moment and very soon reaches its maximum temperature, whereas a coal-fire takes very much longer to do this.

2. When done with, the fire can be put out at once, so that there is no waste of fuel in the fire "burning itself out."

3. There is no heavy and dirty coal to be handled.

4. There are no ashes and cinders to be removed, the removal of which causes much dust in the room.

5. There are no grates to clean, except very occasionally.

Items 3, 4, and 5 are very important to the housewife, especially when she is without a servant.

6. The temperature can be regulated to a nicety.

7. There is less danger of fire.

8. No space is required for the storage of coal, either in the cellar, or in the rooms in which the fires are wanted.

9. The quantity of gas used is very conveniently measured by a meter, and can be easily checked by the user, whereas not one householder in a thousand checks the weight of coal supplied to him, because of the time and difficulty of so doing.

10. Gas cannot be stolen as easily as coal.

11. Lastly, and certainly not the least advantage, especially in the eyes of such a meeting as this, there is *no smoke!*

As to whether the central station for generating the gas should be in the town or close to the coalfields would depend on circumstances. There are certainly very many advantages in having the station by the coalfields, as it would save a great amount of the costly handling and freight of the coal, and the difference in the cost of the dearer site for the station in the town.

It has been objected that the volume of gas would be so great that the mains would have to be excessively large. Fortunately gas is compressible. The pressure at which ordinary gas is distributed is equal to about 3 inches of water, which is equal to 0·108 lb. per square inch (above atmospheric pressure), while in America they are distributing gas at a pressure of 20, and even 80 lb. per square inch (above atmospheric pressure). The volume of a gas is inversely proportional to its absolute pressure, so that in increasing the pressure from 0·108 lb. to 20 lb. per sq. in. (both by gauge) the volume is reduced to *one-half*, and if the final pressure be 80 lb. per square inch, then the final volume is less than *one-sixth* that of the initial.

Another bogey is that the leakage would be great. This is not found to be so in practice. Professor F. W. Burstall stated in evidence before the recent Royal Commission on Coal Supplies that the leakage from the

Paris air-mains (in which the pressure is 100 lb. per square inch) is only 0·4 per cent. per mile, and that the efficiency of transmission is considerably better than in the case of electricity! In addition to this we have had many years of experience of the distribution of ordinary gas.

The Hon. Rollo Russell has proposed that a tax should be put on all houses producing much smoke, in the same way that factory owners are now fined. If the money so collected were used for the producer gas scheme, people would be provided with the means of avoiding the making of smoke and thus of avoiding the tax, while those indifferent to the interests of the community would rightly have to pay. New York has long since taken the far more drastic step of prohibiting the use of any but anthracite (smokeless) coal, and is rewarded with a practically smokeless city.

SMOKE PREVENTION AND COAL CONSERVATION.

By ARTHUR J. MARTIN, M.Inst.C.E.
(M.R.SAN.I.)

SMOKY fogs involve (1) loss of light, entailing large expenditure on artificial light, estimated, in *The St. James's Gazette* of 14th October, 1903, at not less than £7,000 per day; (2) expense from disorganisation of traffic; (3) damage to buildings, decorations, and property of all kinds* †; (4) loss of life‡; during the winter fog of 1879–1880, the deaths were several thousands above the normal, the percentage increases being asthma 43, bronchitis 331, whooping-cough 231; in the last fortnight of 1891, including the 100-hour fog of Christmas, the excess above the normal was given by Dr. Vivian Poore as 1,442; (5) injury to health and impaired vitality.

In Paris or Berlin, or any other metropolis on the Continent, and in New York, prolonged black fogs, such as we have learnt to dread each recurring winter, do not occur, and the secret of this immunity lies chiefly in the difference between their modes of heating and our own.

The "Coal Tables" issued by order of the House of Commons in 1904 give the weight of coal consumed in the Metropolitan Police District during 1903 as over fifteen million tons. On a moderate computation the daily mid-winter consumption is probably not less than one-and-a-third times the average, or say 1,135 pounds per acre per day.

Every pound of coal requires for its complete combustion at least 140 cubic feet of air. Fortunately the products of combustion, which

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* The Hon. Rollo Russell has estimated the annual cost of fogs in London at from three to five million pounds. *Journ. R. San. I.*, Vol. XXIII., p. 330.

† Chief Smoke-Inspector Adams, of Chicago, in a report to the Board of Health of that city, says: "I know of an instance in which a restaurant firm so consumed $600 worth of coal as to cause an actual damage to adjacent property exceeding $25,000."—*Engineering Magazine*, August 1897, p. 796.

‡ *Vide* Sir James Crichton-Browne, *Journ. R. San. I.*, Vol. XXIII., p. 209.

amount to some 5,000,000 tons per week, owing to their warmth and consequent lightness, pass upward, and under favourable circumstances are dissipated by the air-currents. During a black fog, however, as both eye and nose can testify, large quantities of these products drop back to the earth.

Dr. W. J. Russell, F.R.S., systematically recorded the amount of carbonic acid gas in the air of an open space at St. Bartholomew's Hospital from 1882 to 1884. In the absence of fogs, the average CO_2 was 4·03 parts in 10,000, with a minimum of 3 parts. Black fogs were accompanied by a marked increase, the average of twenty-nine fog observations giving 7·2 parts, with a maximum of 14·1. He pointed out the significance of the increase of CO_2 as indicating the presence of more dangerous impurities, and showed that during fogs the air contains appreciable quantities of sulphuric acid, formed from the sulphur in the coal, while hydrochloric acid is also found, to a slightly less extent, and that these acids play an important part in the production of fog.

It is believed that the solid constituents of smoke rarely rise more than a hundred yards from the ground, to which a large proportion of them eventually return. At Glasgow,* in 1904, it was found that over a ton of smut was deposited annually per acre after a week of fog. Sir W. Thiselton Dyer found a tarry deposit on the Kew Gardens green-houses at the rate of six tons to the square mile.†

These and other facts lead unmistakably to the conclusion that the fog nuisance is largely due to the practice of burning bituminous coal. Our Statute of 1273, which made the consumption of "sea-cole" in London a penal offence, long since has been repealed, but New York to-day prohibits the domestic consumption of bituminous coal within the city-limits.

It ought not to be difficult, by means of educational work such as that carried on by the Coal Smoke Abatement Society, to build up a public opinion which would call for legislation to deal effectively with this matter, New York and other American cities have shown how adequate fines can stamp out the burning of soft coal in private houses.

It is probable, however, that the desired result might be brought about with less friction in a different way. Dr. Shaw proposes to discriminate in the rating of properties between those occupiers who void their smoke into the air and those who do not;‡ but differentiation, while practicable

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* *Journ. R. San. Inst.*, Vol. XXV., p. 673. † Ib., Vol. XXIII., p. 324. ‡ Ib., p. 332.

as regards factories, would be difficult and invidious in the case of private houses, unless the line of demarcation were such that it could not be easily evaded or obscured. Such a line fortunately exists, namely that between those premises which are fitted for the combustion of solid fuel and those in which no such fuel is or can be burnt. Dr. Shaw* suggests a parallelism between the smoke-problem and the sewage-problem. As London expends £211,000 per annum for the disposal of its liquid refuse, he asks whether a like sum would be too much to pay for the prevention of aërial pollution. But in dealing with sewage a large expenditure is necessary for sewers, pumping stations and purification works, while for the prevention of smoke no such system of public works is required, and it lies with each householder to eliminate the nuisance so far as his own premises are concerned. The benefit from the disuse of solid fuel does not stop at the resultant gain in the purity of the air, for an important reduction would follow in the cost of dust-collection and disposal. Taking this saving also into account, the municipalities could well afford to remit, say, threepence in the pound from the rates of those whose premises emit no smoke to fill the air and send out no solid products of combustion into the streets.

Pittsburg supplies a notable instance of such a revolution. Its furnaces and domestic stoves formerly burnt bituminous coal, with the result that it was universally known as "The Smoky City." As soon as natural gas from the oil-fields took the place of coal, there was an immediate and marked reduction in the characteristic from which the city derived its sobriquet.† But this natural gas costs about one fifth of the price of gas in London.

If we prefer the radiant heat of an open fire to the use of air as a medium for the conveyance of heat by conduction, as in steam-heating or central stoves, we must substitute for the wasteful and smoke-producing coal fire, a more rational and economical system of utilising the fuel.

The key to the solution of the smoke problem lies then in the supply of cheap gas for cooking and heating purposes; and several varieties are obtainable, as indicated in the following table. The last column shows the cost of the quantity required to give the same amount of heat as a thousand feet of coal-gas, yielding 617 British thermal units per cubic foot. The prices of some of the fuel gases do not cover distribution.

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* *Journ. R. San. Inst.*, Vol. XXIII., p. 319.

† "The Oil and Gas Wells of Pennsylvania." Andrew Carnegie. Macmillan's Magazine. Jan. 1885.

Comparative Table of Gases.

	Heating value per cu. ft. B.T.U.	Cost per 1,000 cu. ft.	Quantity equivalent to 1,000 cu. ft. of coal gas. cu. ft.	Cost of equivalent quantity.
London coal gas ...	617 ...	2s. 0d. to 3s. 0d. ...	— ...	— —
Dowson gas ...	160 ...	0s. 1½d. to 0s. 2½d. ...	3,856 ...	5¾d. to 9⅝d.
Mond gas ...	144 ...	0s. 2d. to 0s. 4d. ...	4,285 ...	8½d. to 17⅛d.
Blue water gas ...	328 ...	0s. 4½d. to 0s. 5d. ...	1,884 ...	7⅝d. to 9½d.
Dynamic gas ...	150 ...	— —	—	— —
	per lb.	per ton.		
Coal	14,000 ...	20s. ...	44 lbs. ...	4¾d.

The calorific value of ordinary coal is therefore six or seven times that of a quantity of coal-gas of the same monetary value, but this advantage is neutralised by the facts that (1) the proportion of the heat which can be turned to account is far less with coal than with gas, and (2) that coal must generally be kept burning for a much longer time than it is actually required. In power production these points are very important. In electric lighting the maximum power is sometimes required only for an hour or two in the whole day, and it is often cheaper to carry the peak of the load by means of a gas-engine than to keep extra boilers under steam for a period necessarily much longer.

Adding to the cost of fuel gas a fair allowance for the gas company's profit and cost of distribution, it is evident that such a gas could be supplied to London, with profit to the purveyors and benefit to the community. It would, however, require a new service of pipes, and before any alternative supply is introduced it will be worth while to enquire whether that which is already in the field can be made to meet our requirements.

Mr. Orme Masson, in his article on Smoke,* estimates that gas, to compete successfully with coal, should cost not more than 1s., or at most 1s. 6d. per thousand cubic feet.

Prof. Vivian Lewes, in his third Cantor Lecture on "The future of Coal Gas and Allied Illuminants," says that "directly it becomes possible to reduce the price of the gas to about 2s. per thousand," its utilization for cooking, heating and power "will become extremely rapid." In the second lecture he gives the present cost of coal-gas, delivered in the holder in large works, at 1s. per thousand, and that of a mixed gas which he proposes, of 14 c.p. and a calorific value of 500 B.T.U., at something

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* Enc. Brit., Vol. xxii., p. 179.

over 9d. per thousand. In Widnes, ordinary enriched coal-gas of 18 c.p., and 650 B.T.U., is actually sold at 1s. 2d. per thousand for lighting, and at 1s. for heating and power. A witness before The Royal Commission on Coal Supplies stated that "you can get a thousand cubic feet of gas for 6d. if you take it away" from the gasworks. I believe the lowest cost at which coal-gas has yet been produced (as a by-product in a large chemical works) is 1d. per thousand c. ft. of 14 c.p. and 500 to 600 B.T.U.* In the development of the by-products of gas manufacture lies one possibility of cheapening the gas.

The last half-yearly report of the Gas Light and Coke Company shows the price of each thousand c. f. of gas sold to be made up roughly as follows:—

	s.	d.	s.	d.
Coal and oil	1	3½		
Wages and salaries	0	3½		
Purification	0	1		
Repairs and maintenance	0	4		
			2	0
Less received for residuals ...			0	8½
Net cost of manufacture ...			1	3½
Distribution	0	4		
Rent, rates, and taxes	0	3½		
Management	0	1		
Sundries	0	1		
			0	9½
			2	1
Less Sundry receipts			0	1
			2	0
Gross profit			0	11½
			2	11½

The heaviest item is coal, of which a million tons were used during the half-year, costing 13s. 4d. per ton, of which probably one-half represents the cost of carriage from the collieries. Each ton yields about 10,000 cubic feet of gas. The carriage of the coal thus accounts for one-half of the net manufacturing cost of the gas.

Turning from gas-coal to the general supply, the cost of conveyance

* Bowman on "Power Gas," Inst. Electrical Engineers, March 16, 1905.

from the colliery to the dock adds at least 1s.* The average value at the pit's mouth of the whole of the coal raised in the United Kingdom in 1903 is given in the "Coal Tables" for that year as 7s. 8d. per ton, while the average price paid by the consumer in London is about 20s., the difference amounting to £9,000,000 per annum.

It has been attempted to save this expense by power-transmission and distribution. In 1892, Mr. B. H. Thwaite proposed to generate electrical energy in the colliery-districts, and to transmit it by cable to the Metropolis and other centres.† Compressed air, which has been in successful operation in Paris since 1870, is another possible medium, but, so far as I am aware, 100 miles is the greatest distance over which it has been proposed to convey it. An alternative method, possessing some very important practical advantages, is the transmission of potential energy in the form of gas.

The prevention of smoke is not the only argument in favour of power-transmission, its main advantages being of an economic nature. The chief of these is the avoidance of the waste due to our present inefficient modes of using coal. An important corollary is the husbanding of our national coal resources.

The following table, by Mr. George T. Beilby, shows the yearly consumption of coal in the United Kingdom, and the saving which may be effected in each of its various uses.

Coal Consumption and Economy.‡

	Consumption in Millions of Tons.	Saving in Millions of Tons.	Means of Economy.
Railways	12 to 14	5 to 7	Gas Generators and Engines, and Electric Motors and Electric Traction.
Steamers	6 „ 8	—	
Factories	40 „ 45	20 „ 30	
Mines	10 „ 12	5 „ 7	
Blast furnaces	16 „ 18	2 „ 3	Gas Engines and Recovery Ovens.
Iron and Steel	10 „ 12	2 „ 3	
Other metals	1 „ 2	—	—
Brickworks, Potteries, Glass works, Chemical works	4 „ 6	1 „ 2	Gas Generators and Coke.
Gas works	14 „ 15	—	Gas-cooking and Heating Briquettes, and Coke.
Domestic fires	30 „ 36	5 „ 8	
	143 „ 168	40 „ 60	

The importance of these savings is not measured merely by the

* Royal Commission on Coal Supplies, 2nd Rep., Vol. II., Ans. 11,935.

† *Engineer*, 2nd December, 1892.

‡ Royal Commission on Coal Supplies, 2nd Rep., Vol. II., Ans. 9,631.

reduction in consumption, since in nearly every instance this implies the supersession of wasteful and smoke-producing modes of combustion by methods which are at once efficient and smokeless.

Electrical transmission, for power-production and lighting, has many advantages; but for heating and cooking it is heavily handicapped by the enormous losses which are inevitable in the production of mechanical energy from coal. Working by steam, not more than about 12 per cent. of the heat-units yielded by coal can be recovered as heat on reconversion, while the loss in transmission and distribution would probably reduce this to under 10 per cent. Gas-transmission, on the other hand, is not only serviceable for all the above purposes, but has also the advantage that the gas is available for the production of heat with a good economy, and in a most convenient form. Another drawback of electricity is the necessity under which it labours of generating and transmitting the power at the precise rate at which it is used. The switching on of a light or motor at a remote corner of the area of supply must be responded to on the instant by a corresponding increase in the power put forth by the generator, as an electrical accumulator, commercially available on the scale required to be of much value in equalising the work of a large generating station, is not yet in sight. The plant must therefore be capable of working at three or four times the average rate of demand, with a corresponding increase in the initial outlay. These considerations apply with almost equal force to transmission by compressed air. But gas can be stored more cheaply and conveniently than any other vehicle for the conveyance of energy, and the storage involves practically no loss, whereas an electrical accumulator, under the best conditions, will not give back more than about 80 per cent. of the power delivered to it. The storage of gas enables the compressing plant to be stopped at any time without interrupting the service.

The idea of gas-transmission first presented itself to me during the latter part of 1893. I was led up to it by the reflection that if it paid to transmit power by means of compressed air under the conditions met with in Paris, it must of necessity be still more advantageous to do so by means of gas, seeing that a cubic foot of the latter would yield forty times as much energy as the same volume of air compressed to say six atmospheres, and that with gas the whole power of the compressors would be available for the transmission, as against say 10 or 20 per cent. with air. An exhaustive series of calculations relating to the thermal and engineering sides of the scheme left no doubt as to its feasibility and advantages. In this research I was, however, anticipated by Prof. Unwin, F.R.S.*

* Prof. W. Cawthorne Unwin, "Howard Lectures," on "The Development and Transmission of Power from Central Stations," pp. 6, 7.

Power-transmission on a large scale from the collieries not only avoids expense and waste in conveying, handling and distributing coal, but also admits of economy in quantity and quality of fuel. The consumption of coal by small steam-plants in Birmingham ranged from 8·5 to 36 lbs. per ind. h.p. per hour, and in electric generating stations it is rarely as low as 3·30 lbs.; while with larger engines it may be as low as 1·3 lbs.,* and with modern gas-engines has even been reduced to 0·768 lbs.†

Generating plant at the collieries can use cheaper grades of coal, not excluding the dust. About 24,000,000 tons of small coal are left as waste every year at the pit's mouth, besides an enormous quantity which is thrown into disused workings. By far the greater part of this is in no way inferior in calorific value to that sent away for sale.

The following are instances of long-distance *electrical transmission* on a large scale:—

Place.	Distance Miles.	Horse Power.	Volts.
Michoacan and Guanajuato, Mexico ‡	100	2,250	60,000
Cenischia, Italy §	38	5,600	30,000
Ogden Canon, Utah ‖	38	5,000	16,100
Cauvery Falls, India ¶	93	7,000	30,000
Yuba Falls, California ¶	222 (and temporarily 270)	15,000	40,000

All these have very high tensions and bare overhead conductors, which it would probably not be possible to employ in this country. Insulated underground conductors increase enormously the cost of the line, and the working potential has to be very much lower. Mr. H. F. Parshall ** gives 20,000 volts as the present safe limit for underground cables, which means either a large increase in the amount of copper employed, or a greatly increased loss in transmission. Moreover, in all the cases cited, the current was generated by water-power, so that the above distances afford no criterion of those over which the transmission of electrical power from coal is commercially possible in this country.

Compressed air has been much less used for long-distance work, the Paris plant, conveying power four or five miles, being probably the largest as yet laid down. In connection with the utilisation of the water-

* Prof. W. Cawthorne Unwin, "Howard Lectures," on "The Development and Transmission of Power from Central Stations," pp. 6, 7.

† Dr. F. H. Bowman, Lecture on "Power Gas." ‡ Proceedings, Inst.C.E., Vol. CLIX., p. 443

§ *Engineering Magazine*, June, 1903, p. 362. ‖ Ibid., May, 1899, p. 313.

¶ *Cassier's Magazine*, April, 1903. ** *Engineering*, 16th June, 1899.

power at Niagara Falls, it was calculated that by air compression 5,000 h.p. could be transmitted upwards of twenty miles, with a loss not exceeding twelve per cent.

Prof. H. Haupt, Consulting Engineer of the General Compressed Air Co. of New York City, calculates that power-transmission by air, compressed by a turbine-driven plant to an initial pressure of 2,000 lbs. per sq. in., to a distance of 100 miles, shows a slight advantage in cost over steam power generated locally, and concludes that if power should be generated at the coal-mines from costless refuse coal, and transmitted 100 miles in pipes, the cost for 2,500 h.p. would be:—interest, repairs, and depreciation of the boiler plant, \$9,375; wages of firemen, \$2,700; of engineers, \$4,000; interest and repairs on compressor plant, \$12,000; interest on pipe-line, \$15,000; total, \$43,075, or \$17 per h.p. per annum, which is nearly \$10 less than the cost of steam-power generated locally.*

In *gas-transmission*, except for the ordinary city-supplies, some of which are piped to very respectable distances, little has yet been accomplished. Proposals were made to the Royal Commission on Coal Supplies by Mr. Beilby, (9,563), Prof. Burstall (10,495–7), and Mr. R. Threifall, F.R.S. (14,188). The most notable undertaking is that of the South Staffordshire Mond Gas (Power and Heating) Co., formed to supply an area of 163 square miles, between Birmingham and Wolverhampton. Their charge is from 4d. to 2½d. per thousand c. ft., or lower for quantities exceeding 5,000,000 feet per quarter. Their 4,285 c. ft. of gas at 140 to 148 B.T.U., costing from 1s. 5d. to 10¾d., are equivalent to 1,000 feet of coal gas, worth, in the district, 2s. 5d. Mond gas will probably be extensively supplied for consumption within a moderate distance of the generating station, but its low calorific value and the large quantity consequently required militate against its adoption for long-distance transmission. The same applies to producer and Dowson gas, and in less degree to blue water-gas, with its 328 heat-units per c. ft. The much greater calorific value of ordinary coal-gas renders it peculiarly suitable for this purpose, and outweighs its greater cost, due in great measure to the exacting requirements to which it has to conform, which, reasonable enough with the old-fashioned burners, are needless with incandescent mantles, and out of place for heating, or generation of power. An agitation for the abolition of these restrictions has been on foot for some years, and the hardship of having to pay for "enrichments" which are of no use cannot be perpetuated much longer. The following calculations are

* *Engineering Magazine*, July, 1895, p. 770.

based on the generation of coal-gas at the pit's mouth, and its transmission under pressure to wherever it is required for use.

A Pipe Line to Supply all Fuel Used in London.

Case I.—I assume that it is required to generate gas in the Yorkshire coalfields and pipe it to London, a distance by rail of about 173 miles, in sufficient quantity to take the place of all the coal consumed there on a winter day. The calorific value of one day's coal, taken at 55,115 tons, at 14,000 British Thermal units per pound, is about $1\frac{3}{4}$ billion units (1,729,000,000,000 B.T.U.). With coal-gas at 617 B.T.U. per c. ft., the volume required (at atmospheric pressure) will be 2,802 million c. ft. per day. A single line of 6 ft. pipe will deliver rather more than this quantity of gas with an initial pressure of 480 lbs. per square inch. If welded steel pipes are used, the total weight of steel required will be about 270,000 tons. The longest steel pipe line of which I have reliable data is one 352 miles in length for the supply of water to Coolgardie (see last session's Proceedings, Inst.C.E.). The total cost, with all charges, was £1,870,000, equal to £5,312 per mile, or £28 per ton. In this country £28 per ton would probably cover all expenses, and 270,000 tons at £28 = £7,560,000.

To compress 1,946,000 c.f.m. down to 480 pounds per sq. in. requires about 439,300 effective h.p., or, allowing a total efficiency of 77 per cent.,* 570,500 indicated h.p. If the whole were used in large gas-engines, these would develop about 9,000,000 indicated horse power. The power expended in transmission is thus under six per cent. of the whole. In electrical transmission the loss would probably be from twenty to thirty per cent.

Case II.—The foregoing case proves that a single line of pipe six feet in diameter is capable of doing the work of the 550 † coal trains required to carry to London the coal burnt there on a single winter's day, and (in conjunction with the existing distributing mains) of the horses, carts, and men to bring it from the rail to our cellars. It would not be prudent to entrust the whole supply to a single pipe line, or even to a single route, and at the present time it would be difficult to obtain 6-ft. steel pipes of the thicknesses required to withstand the heavier pressures. Moreover, it would not be economical to use pipes of the same diameter throughout, since the high velocities towards the point of delivery would cause that part of the main to absorb far more than its due proportion of

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* Unwin. Proceedings Inst.C.E., Vol. CV.

† Allowing 100 tons per train (R. C., 11529).

the pressure available for transmission. A more advantageous arrangement would be to lay down four lines of pipe, each ranging from 36 inches in diameter at the coalfield to 72 inches at the London end, and capable of conveying a maximum daily volume (at atmospheric pressure) of about 700,000,000 c. ft., with an initial gauge pressure of 510 lbs. The weight of the four lines would be about 320,000 tons, or less than 20 per cent. greater than that of the less economically arranged 72-in. pipe.

To work the compressors 148,710 indicated h.p. would be required for each line, or 594,840 h.p. in all. If power had to be generated specially for compressing the gas, the most economical plant, from a fuel point of view, would consist of producers and gas-engines, in which an indicated horse power might be obtained for about 0·8 lb. of coal per hour. At this rate a compressing plant capable of working the four lines to their full capacity would consume 5,200 tons of coal per day, which is probably not far off what would be required for 550 locomotives hauling London's daily quantum of coal, and the shunting engines in the yards. There happens, however, to be a source of power already available, in the gases of combustion from the coke which is burnt for the purpose of carbonising the coal. These gases pass off from the retort ovens at a very high temperature, and if, instead of going to waste, they are passed through suitable boilers, enough steam can be raised by their means to work the compressors, thus obviating the need for more fuel. In addition to the heat thus available in the gases of combustion, a further supply is stored in the coke derived from the coal which is carbonised in the retorts. This heat is generally wasted by the quenching of the coke with water; but M. Emile Gobbe has recently invented a method for its recovery. This consists in feeding the incandescent coke as it comes from the retorts into a vertical producer, called a "quenching" producer, into the base of which a spray of water or jet of steam is led. This quenches the coke, the heat from which dissociates the steam, the oxygen combining with a portion of the carbon to form carbon monoxide, and the hydrogen being left in the free state. The heat of the coke is thus utilised for the production of water-gas, yielding a practically costless but valuable fuel, which can be used either for raising the coal from the pits, for compressing air to work the machinery below ground, or for heating the retorts, thus saving an equivalent amount of coal or coke. The steam required for working the gas compressors being thus furnished by the manufacture of the gas, we have only to take account at the power station of the engine-room costs and that of management, which for such large installations as we are now considering, and for absolutely steady work, might be taken for present purposes at 20s. per indicated h.p.

per annum. The average daily load being three-fourths of the maximum, the power consumed will be reduced in a somewhat greater proportion, but taking it at three-fourths it will amount to 446,130 indicated h.p.

The first cost and working expenses of the transmission-plant will then be as follows:—

First Cost of Transmission Plant.

Boilers, engines, compressors, and auxiliary plant	594,840 I.H.P.		
Add reserve 20 %	118,968		£
	713,808	@ £14	9,993,312
Pipe-line, including all costs, 320,000 tons ...		@ £28	8,960,000
			£18,953,312

Say £19,000,000

Annual Cost of Transmission.	£
Wages and management, etc., 446,130 I.H.P. at say 20/-	446,130
Inspecting and painting pipe-lines when necessary, say...	20,000
Rates, taxes, and insurance, say	33,870
	500,000
Interest on investment at 4 %	760,000
Depreciation on buildings and steam plant, at 7½ %, say	750,000
Depreciation on pipe-line, at 4 % ... ... say	360,000
	£2,370,000

This is only just over two-fifths of the bare railway-charges for carrying an equivalent amount of coal to London by rail, or one quarter of the difference between the value of the coal at the pit's mouth and as delivered to the consumer. Spread over the gas transmitted, the cost of transmission works out at three farthings per thousand cubic feet.

A Pipe Line to Supply The Gas Light and Coke Co.

Case III.—This Company made during the first half of 1905 11,283,976 thousand c. ft. of gas, the maximum daily consumption being say 125,000,000 c. ft. This quantity could be conveyed from the coal-fields by a main ranging from 18 in. to 36 in. diam., weighing 25,000 tons, and worked under an initial pressure of 510 pounds per sq. in. In

this main one ton of steel is required for each 5,000 c.f. of gas carried per day, as against 8,750 c.f. in the last case. The cost of transmission per thousand c.f. would therefore be a shade higher than in Case II., but would still be under a penny.

In the foregoing no account has been taken of leakage. In the Gas Light and Coke Co.'s system 6·2 per cent. of the gas made is unaccounted for, through losses in the works themselves and in the mains and service pipes. The leakage from a system of gas-mains, of varying ages and conditions, tapped at short intervals and connected with a ramification of pipes, good, bad, and indifferent, affords no criterion applicable to a new main not used for distribution. The best of the Paris air-mains lost in each mile 0·38 per cent. of the amount delivered; but Professor Riedler believes that in newer and better laid mains the leakage is considerably reduced.* At Offenbach, under a pressure of $6\frac{3}{4}$ atmospheres, the loss was only 1·6 c. f. per mile per hour.† A loss even at the rate of 0·38 per cent. per mile would obviously be a very serious matter on a 173 mile line, amounting as it would to two thirds of the gas delivered, or two fifths of that sent out. Steel tube makers, however, are prepared to lay pipe-lines which will be practically gas-tight; and Prof. W. B. Burstall, considers that the leakage from long pressure mains can be reduced to considerably less than one-tenth per cent. per mile.‡ This over a 173-mile line would amount to 17·3 per cent. of the gas delivered, and, spreading the cost of the gas thus lost over that sold, the price of the latter would be correspondingly raised. The monetary loss by leakage of gas would probably not exceed that by waste of coal in transit and handling, and its deterioration for gas-making purposes by lapse of time.

In the foregoing statements no credit is taken for the possibility of using small coal, worth from 3s. to 4s. per ton,§ or less, or for the immense heaps of waste coal which might also be brought into use. It might, however, be better to hold this material in reserve for emergencies, in order to prevent those disastrous fluctuations in price to which coal is subject. In 1900 and 1901, for instance, the value of coal at the pit's mouth rose from 7s. 7d. per ton (in 1899) to 10s. $9\frac{3}{4}$d. and 19s. $4\frac{1}{4}$d. respectively.

A saving in the manufacture of gas would be brought about by modern works erected on an ample site, and the configuration of the ground at most collieries will permit of arranging the plant much more advan-

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* Unwin—Distribution of Power by Compressed Air. Proc.Inst.C.E. Vol. CV.

† Unwin—Howard Lecture on The Development and Transmission of Power, p. 65.

‡ Royal Commission, 10,495. § Ibid., 14,811.

tageously than is possible on the flat sites in and around the metropolis. A close calculation of the saving which may be expected to result from the transfer of the manufacture of gas from London to the coalfields could not safely be made without much fuller data than I at present possess, but I have shown that there is a fair probability that the light and heat which we require can be brought to us for a fraction of the £9,000,000 a year (over and above the value of the coal) which we have to pay for its carriage and handling. That something like three quarters of this can be saved appears to be beyond doubt.

As to the effect which the change will have on the selling-price of gas in London, if it were merely a question of railway versus pipe, the saving might be arrived at by deducting from the present price the difference in cost of the two modes of transmission, less the interest on the capital cost of the new manufacturing plant at the collieries. Other considerations affecting the result are the possibility of using a cheaper grade of coal at the collieries, the saving in labour due to up-to-date plant with ample space, the difference, one way or the other, between the rate of wages in London and that in the collieries, and the abolition of standards of illuminating value. It is probably not too sanguine to expect that gas will be delivered to the compressors at 6d. or at most 8d. per thousand cubic feet, as against 5·84d., the actual net cost of manufacture and distribution at Widnes. If this expectation is borne out, the gas will be delivered at the Companies' works in London at 8d. or 10d. per thousand cubic feet, which will admit of its being retailed to the consumer at a price considerably below the present. This forecast is put forward with diffidence, and may be superseded by more reliable estimates.

But the customer must not expect to receive in his gas the same calorific value as he now gets in his coal. If this were attempted, the result would be disastrous for coal-conservation, since close on five tons of coal would have to be carbonised to furnish gas equal in heating value to one ton. The volume of this gas would be about 50,000 cubic feet, and to compete in heating value with coal at 23s. it would have to be sold at 5½d. per thousand cubic feet, which is not within the bounds of probability. The saving point is that for all domestic purposes a far larger proportion of the heat can be turned to useful account with gas than with coke or coal. Hence the estimates, which have already been quoted, that gas at 1s. or 1s. 6d. per thousand cubic feet is cheaper to use than coal at current prices.

In power-production also the same applies, as will be seen from the following statement, showing the cost per Board of Trade unit of the

fuel used by the twenty-five Metropolitan Electric Light undertakings during twelve months, and the price at which gas must be supplied to enable them to obtain the same power by means of gas engines at the same cost for fuel, on the basis of 22·6 c.f. of gas per unit generated, and 115 units generated for each 100 units sold.

	Cost of Fuel per Board of Trade unit sold.*		Equivalent price of gas per 1,000 c.f.
Highest cost of fuel (Islington)	1·03	...	3s. 4d.
Lowest cost of fuel (Hackney)	0·32	...	1s. $0\frac{1}{3}$d.
Average cost at 25 works ...	0·65	...	2s. 1d.

Thus coal-gas at 1s. per 1,000 cubic feet would be a cheaper fuel than coal for every generating station in the metropolis.

The gain to the atmosphere of London would therefore be twofold, owing, firstly, to the greatly reduced consumption of fuel brought about by the superior efficiency of gas as compared with coal; and, secondly, to the perfection with which that combustion would be effected.

From a coal-conservation point of view, this greater efficiency of gas is very important, for if, to do a given amount of work with gas, the same number of heat-units were necessary as in the case of coal, at least four times as much coal would be required to furnish that gas as would suffice to do the work direct. Even as it is, it is probable that the weight of coal which would have to be carbonised to supply London with gas would exceed that which is now consumed for all purposes; but as a set-off each ton of coal would yield some 13 or 14 cwt. of coke and breeze, or, allowing for the quantity required to heat the retorts, 10 or 12 cwt. available for sale. The return from these alone would be not far short of the value of the coal from which they are derived.

So valuable is coke for making pig-iron, and for foundry purposes, that of the 12 million tons which are made each year for the purpose, close on 11 million tons are produced in open ovens, with the result that the whole of the gas and other valuable residuals are lost. The removal of the gas-manufacturing industry to the coalfields would effect a great national economy, by furnishing an outlet for the utilisation of the gas from the coke ovens, and thus doing away with this appalling waste.

Any doubt which may exist as to the commercial practicability of gas-transmission will be best dispelled by a consideration of some achievements in the same direction with natural gas in the United States.

This gas (which contains practically the same constituents as our coal-gas) is obtained from deep borings in the gas districts of several States, and

* *Electrical Times*, 21st Sept., 1905, pp. 387, 389.

the greater part of it is piped to distant points. From 10 to 12 million cubic feet per day are pumped from the Indiana gas-fields to Chicago.*

Much of the gas from Northern Pennsylvania is sold in New York, and some points of consumption are more than 200 miles from the gas wells. The total production in 1903 was 238,769,067,000 c.f., equivalent in heating value to close on 12 million tons of bituminous coal. Four million people are supplied with light and fuel (for all purposes) by natural gas. The compressors which force the gas to Chicago are capable of producing a pressure of 2,000 pounds per square inch, and work at a normal pressure of 300 pounds. Several of the pipe-lines in West Virginia are from 16 inches to 20 inches in diameter.†

Hence as regards its magnitude, the number of people supplied, the distance, and the pressures, the natural gas industry of the United States affords good precedents for the project which I have outlined. The question will naturally arise whether manufactured coal-gas, with its initial cost of production, will stand the additional expense of transmission. This is conclusively answered by the fact that the average price to the consumer of natural gas in 1903 was about 15 cents per thousand c. f. If the price at the wells is taken at the extremely low figure of 3 cents, this leaves only 12 cents to cover the cost of transmission and distribution. My estimated cost of transmission, namely, 1d. per thousand c.f., added to the 4d. per thousand which it costs the Gas Light and Coke Co. to distribute their gas, gives 5d. for these two items, as against 6d. in the foregoing.

Another instance of long-distance transmission is the piping of petroleum from the oil-fields to New York harbour, over 400 miles. The main trunk line consists of three 6-inch wrought iron pipes, with twelve pumping stations some 35 miles apart. The pumps work at about 1,000 pounds per sq. in. pressure, and the capacity of the line is about 105,000 imperial gallons per day.‡ The average price of Pennsylvania petroleum was $1·59 per barrel, or £9,540 for the day's flow, which is only a quarter of the amount of London's daily coal-bill. The annual selling-price of the maximum quantity of water delivered by the Coolgardie pipe-line is £319,375, the cost of the pipe-line and pumping stations being £2,300,000, or 7¼ years' earnings. A conduit and compressor-station to deliver sufficient gas to meet all London's requirements for fuel can be laid down for £19,000,000, only 2½ years' purchase of the saving which it would bring about.

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* "The Harnessing of Niagara," p. 348.

† U.S. Geological Survey Report. Mineral Resources of the United States, 1903.

‡ "The Harnessing of Niagara," p. 347.

In London the substitution of gaseous fuel for coal will save the army of carts which convey the coal to our houses, and would lessen the number required to remove the ashes, etc. Wherever gas under pressure can be obtained, and it will pay to lay a separate pipe, compressed gas will be available for locomotives, both on road and rail, thus paving the way for a stinkless motor. A cylinder $5\frac{1}{2}$ ft. in diameter by 30 ft. long will hold, at 500 pounds pressure, enough gas to run an ordinary train for 100 miles, while the expansion of the gas could probably be utilised to cool the cylinder, thus saving a water jacket.

If the pipes are to follow new cross country lines in preference to the existing roads, it is worth considering whether the opportunity should not be taken of forming motor-roads alongside. Motorists should be prepared to pay a good proportion of the cost of new roads for their own exclusive use.

QUESTIONS OF PROCEDURE.

There is one important question remaining to be considered, namely, who are the best persons to carry out a scheme of long-distance gas transmission. So far as their own needs are concerned, the existing gas companies could appropriately lay down and work the pipe-lines. In view of the many interests involved, as for instance the companies owning the collieries, several of which could with advantage feed one pipe-line, those dealing with the residuals, the owners of the pipe-lines, and the gas companies, municipalities and private individuals drawing gas therefrom, it has occurred to me that it might be best to institute some sort of clearing house, on which all parties could be represented, and which would settle the scale of charges for the function performed by each, and deal with all disputes which might arise. Such an institution would obviate the necessity for many large transfers of property, as well as for vexatious and hampering restrictions of the right to supply.

Any piecemeal procedure involves a risk of the interests of the undertakers and those of the public being sacrificed by protracted struggles in the committee-rooms and in the law-courts, ending in compromises satisfactory to no party and irksome to all. Moreover, questions will constantly arise concerning the points on which the interests of a company may conflict, or seem to conflict, with the well-being of the public, and while any false step in the one direction may result in catastrophe, an error in the other may stifle an industry by a well-meant, but shortsighted, code of regulations. Normally, I presume, any questions of the kind would be dealt with by the Board of Trade, but in view of the present clamour

for increased attention to questions of trade and commerce, it hardly seems desirable to overload that Board with other matters. Moreover, the ground to be covered is so vast, and the technicalities so intricate, as to call for the undivided attention of a strong Board, which should have the fullest possible powers, and should deal with the technical side of all Parliamentary Bills which relate to matters within their purview.

Resolution.

I therefore beg to move the following resolution, namely: That in view of the need for husbanding our coal resources, the deplorable and increasing evils produced by smoky fogs, and the desirability of providing a cheap smokeless fuel for domestic and industrial use, the Councils of The Royal Sanitary Institute and the Coal Smoke Abatement Society be asked to join in a memorial to His Majesty's Government, setting forth the urgency of these questions, and praying that His Majesty's Government will be pleased to appoint a strong permanent committee to deal with them.

[*This Discussion applies to the subject before the Conference on Wednesday morning—"Domestic Smoke Abatement."*]

Mr. W. H. Atkin Berry (London) said Dr. Des Vœux had stated that coal had been used as fuel in London for the last 500 years. Macaulay had recorded in his History that King William III. had transferred his residence from London to Hampton Court, on account (amongst other things) of the smoke from the many chimneys in London which mingled with the fog. So that for over 200 years, at any rate, that state of things had been going on in the metropolis. But he (the speaker) believed that it was going to mend now that public and scientific attention is being directed to the evil and to the questions of its remedy as at the present time. He held strongly in favour of gas, both for domestic heating and cooking, and his opinion had been arrived at by experience and experiments, following upon a strong prejudice against gas fires. The great improvements effected in gas stoves during recent years had altered the conditions of the question. It must not, however, be supposed that he argued that coal was to be abandoned as hopeless in connection with the problem of smoke abatement. The Coal Smoke Abatement Society had secured abundant evidence

that the use of coal was by no means inconsistent with abatement of smoke, and had convinced them that under proper conditions and proper management the existing state of things was preventable as regards the fouling of the atmosphere with excessive smoke, and the necessary steps for preventing it should therefore be adopted. The Coal Smoke Abatement Society, in connection with H.M. Office of Works, had recently been carrying on a series of tests of grates, and although the final results have not yet been determined, satisfactory evidence had been afforded that much can be accomplished by the adoption of a proper kind of grate for coal fires.

MR. T. C. HORSFALL (Macclesfield) said that there was no doubt that a community, by the enforcement of a well devised law, could free itself in great measure from the nuisance of domestic smoke. Three years ago he had met a number of German officials who had come to England to study our experiments in housing. They told him that they had been painfully impressed in London and Birmingham by the filthiness of the air and asked him why we English do not prevent the production of smoke by house fires. When he told them that there is no law here to interfere with the making of smoke by householders, they assured him that German communities were not so helpless, and that in some German towns, of which Hanover was one, the amount of smoke made by house fires was now only about one third of that which was produced ten years ago. He knew by his own experience that domestic fires need not produce a tenth part of the smoke they now do. He heard the late Sir William Gull say that he had used an Arnott grate for twenty-five years, and regarded that kind of grate as a cure for the smoke evil so far as houses in which servants are kept are concerned. He himself had used the Arnott grate for more than twenty years, and he had formed the same opinion. The Arnott grates which he had in four rooms burnt common bituminous coal in open fireplaces and warmed his rooms very efficiently and supplied them with fresh air. The fires, half an hour after being lighted, were smokeless for the rest of the day, and if the cinders from the previous day's fire were used for lighting the fire with, no smoke was made. The flue-pipes did not need to be swept more than once in four or five years. One flue that was very much used had not been swept for seven years. He would be glad to send an Arnott grate to London to be tested by the Coal Smoke Abatement Society.

DR. ORMANDY (Warrington) said Dr. Des Vœux made a very strong point in favour of the use of gas not only for cooking, but also for heating purposes generally. One point which struck him was the impracticable nature of many of the proposals put forward. It was admitted that the greater part of the smoke issued from the innumerable chimneys of dwelling-houses, and was particularly evident in the early hours of the morning, at noon, and in the early

evening, in other words, during the cooking periods. Dr. Des Vœux rightly pointed out that a great objection of the use of gas fires in the kitchen, would be the consequent doing away with the hot water supply at present so largely arranged to work from the kitchen fire. This difficulty it was proposed should be overcome by the use of slow combustion stoves with hot water jacket. He desired to point out that the greater quantity of the smoke produced came from the innumerable thousands of small dwelling-houses. It was absurd to suppose that builders would go to an expense such as thus suggested, and still more absurd to think that the tenant would take the matter on his own shoulders. Beyond educating the public gradually to do the best with the existing facilities, the only hope for new action lay in persuading builders of new tenements to adapt these more up-to-date methods of economical and smokeless combustion. With regard to the papers of Mr. Ackermann and Mr. Martin, these both seemed to fail to realise that a tremendous amount of fuel was burnt with the object of raising steam for purposes other than that of power production. There were also very many manufacturing operations which it would be most uneconomical to carry out by means of gas firing. As regards the generation of power there is little doubt that the gradual introduction of the internal combustion engine will do much to diminish the smoke nuisance.

Mr. Marsh (Manchester) stated that as a Manchester man he could not agree that the manufacturers of that district were careless as to the sanitary condition of their surroundings, and that from his experience of them he felt sure they rather courted any criticisms than shunned them. He was delighted to think that the districts round Manchester were at present in the van of progress as regards smoke abatement. The efforts of the manufacturers to abate smoke were probably not caused by any æsthetic ideas, but from a desire to economise, it being well known where there was great smoke there was great waste. To give a proof of what was being done, he remarked that at works with which he himself was connected some 700 mixed coal and coke fires had been converted to gas fires. The stoves referred to were Timmen's stoves. There was now no trace of smoke, and a further recommendation was the greater cleanliness in the works, immunity from fire, and economy in labour of carrying away the refuse, which, in the case of so many fires in one building, is a matter of no little moment. He was of opinion that this class of stove should be adopted by the tinplate workers throughout the kingdom. Then in respect to power, he might say that the works referred to was driven entirely by gas engines. In the district of Manchester a considerable number of gas engines of large power, varying from 250 h.p. up to a thousand h.p., had recently been erected. The mills and factories were therefore doing their utmost to reduce the amount of smoke in the atmosphere, but the domestic house fire, as previous speakers had stated, was the great culprit, and he was afraid that no radical improvement would take place until these coal fires were displaced by gas fires. He was not a believer

with those who thought that restrictive laws would be of much service. Educational influences such as those exerted by Sir Wm. Richmond's society and other kindred societies have had, and are having more effect than all the laws on the statute book.

COUNCILLOR W. MUIRHEAD (Liverpool) said, in matters of smoke abatement the readers of papers had forgotten the obvious usefulness of electricity, both for motor power and for heating; the writer having found a bedroom electric radiator much superior to other methods for its purpose. In speaking of the injurious effects of smoke, the noxious fumes from gas when used either as an illuminant or for motor power must be considered. Although a certain amount of smoke might come from electric generating stations, still this was local and comparatively limited. Far more could be done by educating the people and conferring with builders and architects than by supporting such drastic legislation as that proposed in some of the papers. In many cities and most small towns the gas was not a public asset, but belonged to a private company, and until the powers of private companies were limited, more especially as to the manufacture of poisonous water gas, great care should be exercised in putting more power into their hands. As regards the use of coke it must be remembered that at the present time the supply was limited and any further great demand would enormously increase the price.

MR. B. H. THWAITE (London) said that the suggestion that broken coke from by-product recovery-coke ovens should be used instead of soft coals in grates, was the best and most immediately practicable remedy put forth; but with the proviso that in the coking of the coal for the specific purpose named, the coking operation should not be carried to the full period of exhaustion, but should be arrested at a point a little beyond that of an ordinary retort gas making process, so as to permit some proportion of the hydrocarbon to be retained with the coke to assist in its ignition, and in the maintenance of combustion. The expenditure of 8 to 10 cubic feet of gas should be ample to effect the ignition of the coke. He had seen the domestic coke and open fires in Sir Chas. Cookson's house, and could confirm his statements. There should be no difficulty in adopting this method of domestic heating if the scheme of coke and electric bulk power production, referred to in the postscript to Sir Charles Cookson's paper, is adopted,* and which would remove the smoke disgrace of London. He utterly disagreed with the *laissez faire* policy of our government, regarding the methods of arresting the production of smoke by the householders of our great cities; if this free and do as you like principle continued, there was little hope that the smoke nuisance *would ever be removed.* The suggestion in Sir George Livesey's paper that the illuminating value of town gas should be reduced

* A copy of a reprint of this article had been handed to the Secretary.

to 8 to 10 candles, he thoroughly agreed with. The reason for the high illuminating standard value, involving the use of expensive enrichers, *disappeared* when the Auer-Welsbach invention was perfected, now some 15 years ago, and the continued insistence of the present lighting standard by our authorities is unwise. The use of the low candle power gas preferably produced in by-product recuperative coke ovens, would permit the economic production of such gas, of the proposed reduced standard value of 8 to 10 candles. The coke oven combustion chambers could be fed with producer gas made from common slack coal, the coal for producing coke could be selected from coal having low sulphur-content qualities.

Mr. Ernest A. Dowson (Birmingham) said that he had read Mr. Martin's paper with much interest, and agreed with him that ordinary coal gas was more suited for general distribution over a wide area than was any kind of semi-water producer gas. The latter was in its own special field when converted into power and heat in the vicinity of the works where it was generated, rather than for transmission to great distances. As pointed out by the speaker in a recent paper read in Birmingham, the point was of *fundamental* importance in connection with the firing of large furnaces. To ensure success and the greatest economy in these cases, they should endeavour to avail themselves of the hydrocarbons, and thus obtain as much *radiant* heat as possible from the luminous flames given. Passing to the question of the warming of apartments by the direct combustion of producer gas, which was certainly a useful application of this fuel, there were one or two points which occurred to him to mention. For well-known reasons it was advisable to take more care in the use of this kind of gas; and in his opinion the stoves should be designed as far as possible to ensure that, in the event of the flames becoming unintentionally extinguished, the unconsumed gas shall pass entirely to the chimney without any escape to the apartment. For the same reason he would advise that, in every case where this gas was burnt in a small or closely confined room, a pilot-flame of ordinary coal gas should be kept alight adjacent to the nozzles in the grate. This would then ensure the automatic relighting of the fire after any temporary interruption in the supply of the producer gas. He did not wish to appear an alarmist, but it was very important to avoid getting a bad reputation for the system merely for the want of taking reasonable precautions, especially remembering that the public took a long time to educate in new methods. Although he was specially interested in the application of gaseous fuel, he nevertheless felt that there were cases where the combustion of solid fuel at the point of application would always be called for. It is thus of extreme importance, from every point of view, that furnace design shall continue to receive expert attention. A previous speaker (Mr. Councillor Muirhead) had suggested the possibilities of electrical heating, but, apart from its financial aspect, this side of the subject failed to touch the root of the matter. All

would see that they must go some steps further back, to the generating station, where they were again faced with the problems which were being discussed by the bodies under whose auspices the conference was held.

MR. THOS. POTTERTON (London) said that one of the speakers in the discussion remarked that the heating of water by gas was too expensive for ordinary use in small houses, and suggested that it could be done from a small boiler with coke as fuel. He would like to state that water for domestic use could be most economically heated from gas. With 27 ft. of gas he could obtain a bath of 20 galls. at 90° Fahr., and if a second bath was required, the gas being kept burning, 27 ft. consumption would yield a bath at 100° Fahr. It should be noted that in the first instance the apparatus was quite cold, while in the second the water was partly heated, which accounts for the difference. These figures represented winter conditions, so that in the summer the cost would be less. It would therefore be seen that for workmen's dwellings where slot meters were provided, by placing one penny in the slot a hot bath could be obtained.

DR. K. E. MARKEL (Warrington) speaking as a delegate from the "Beautiful Warrington Society," pointed out that a very important point with regard to the damage done to property by the products of combustion had not been brought forward, a point which was especially significant at the present moment, when the Charing Cross railway disaster would be fresh in their minds. The fact that the oxidised product of the sulphur in the coal condensed on surfaces and formed sulphuric acid was not generally apprehended. Nor was it sufficiently recognised that this was a progressive reaction. Yet this it was which explained the enormous damage done by comparatively small quantities of sulphuric acid in contact with iron. The sulphuric acid not only dissolved iron in the first instance, but acted afterwards as a kind of intermediary agency between air and iron, going on eating through the iron as practically no other substance would do. When polished iron was exposed to a smoky atmosphere it would be observed that after a short time the bright surface was covered with fine specks of soot, followed soon after by specks of rust, the soot thus forming centres of corrosion. The sulphurous acid originally condensed in the soot had become oxidised into sulphuric acid, and this it was which was responsible for the corrosion. As this corrosion, or conversion of iron into rust, was so important a question, he thought it worth while explaining it chemically. In the first instance on contact of sulphuric acid with iron, ferrous sulphate was formed. This ferrous sulphate took oxygen from the atmosphere and was converted to another substance called "basic ferric sulphate," which, again, in contact with iron was converted into ferrous sulphate and iron oxide or rust. The ferrous sulphate would again become oxidised in the way just described and again reduced by contact with iron, and this process would continue until the whole of the iron was eaten through. The large quantity of a million tons of sulphuric

acid, of which Dr. Rideal had spoken in his paper, afforded no measure of the damage done unless one took into consideration that important and as yet little recognised fact of the progressive action of sulphuric acid on iron. He also pointed out that if manufacturers had recognised combustion to be a purely chemical reaction enormous economies could have been effected throughout the country, together with abatement of smoke from factories. He himself had adopted a plan of placing the management of all furnaces and boiler fires in his works in the hands of chemists, with results equally astonishing whether one regarded the abolition of smoke, or the increase of furnace efficiency and boiler power. His advice to all engaged in manufactures in which combustion of fuel played a part, would be therefore, "supplement your engineer by a chemical expert."

Mr. J. Macaulay (Liverpool) said that Sir C. Cookson did not state how he would prevent the coke ash from choking the holes of the Bunsen burner which he placed under the grate, nor how he would prevent it from flying over the furniture when the fire was disturbed. Then again, there was the old nuisance of smoke if coal and wood were used to light the fire each morning in the ordinary way. The fact remained that common coke made a dirty ashy fire from which very much sulphur was given off.

Thursday, December 14th, 1905.

SUBJECT: "FACTORY & TRADE SMOKE ABATEMENT."

ADDRESS

By SIR WILLIAM H. PREECE, K.C.B., M.Inst.C.E., F.R.S.

(VICE-PRESIDENT & F.R.SAN.I.)

I REMEMBER reading in the autobiography of Benvenuto Cellini (1500–1572), some comparisons he drew between the climate, clearness of atmosphere, and blue skies of Florence and Paris, to the great advantage of the French capital. What would he say now? I have seen Paris dressed in a real good London fog; and the reason given was that the French, like the English, have taken to burn coal regardless of economy and consequence. On the other hand, I have only just been reading an admirable comparison between Birmingham and Berlin, from the brassworkers' point of view, recording the observations and conclusions of three Birmingham social reformers, without political bias, in a ten days' visit during last April to the Prussian capital. They went really to inquire whether the brassworkers in that city have succeeded in attaining a more desirable physical and industrial life than that led by the brass-workers of Birmingham. The report is most interesting. It is published by Hudson & Son, of Birmingham, for one penny. Berlin has a population of 2,000,000. It is a city of cleanliness. They visited some workmen's dwellings. The report says:

> The heating stove was a beautiful structure about 8 feet high by 3 feet wide by 2 feet deep, built of glaze white tiles. There is scarcely any heat wasted in these stoves, and one cannot see the fire as in an English fire-grate, as it is all closed up with double doors. There is no dust or smoke

of any kind from this class of stove. It is not easy to convey to anyone who has not seen one of them the exact idea of what they are like, but that they serve the purpose of heating the room in a most uniform and economic manner is at once apparent. The stoves can best be described as large radiators, and give out the heat to great advantage. The fuel used is not ordinary coal, but a patent fuel, which is in oblong blocks of about the size of half a brick, and costs about 1s. per week, and may have something to do with the comparative absence of smoke in Berlin.

Here is another reason from Germany! "It is evident," says the report, "that the Berliners have made this cleanliness the starting point in beautifying their city, and in all their social relations." If cleanliness is next to godliness, then must cleanliness rank first in the class of sanitation. Pure air, pure food, pure water follow next, and pure soil, pure dwellings and pure bodies bring up the rear. Cleanliness and purity lead to health and to economy. It is to these last two points that I wish to direct your attention in considering and discussing the abatement of smoke.

During the last few days we have had a great object lesson. London has been fog-blocked. I was kept late last Monday night an hour and a quarter outside a metropolitan railway station because the impenetrability of the air to light, owing to its deep saturation with water globules, rendered all signalling operations impractical. What is the connection between smoke and fog? The air is always charged more or less with moisture. Pure water in the gaseous state is perfectly transparent, and the amount of humidity in every cubic metre of air is easily measurable. There are certain points of pressure temperature and impurity of the air when the otherwise transparent vapour will condense into cloud and rain. Each particle of matter suspended in the air becomes a nucleus round which molecules of water assemble, becoming opaque and therefore visible. Every single being who breathes fog-charged air has ocular demonstration on his pocket-handkerchief that his mucous membranes are clogged with black particles. These have been proved to be carbon, and it has been shown that carbon particles are the cause of the density and darkness of London fogs.

The presence of carbon particles in the air is a proof of the imperfect combustion of coal in our domestic as well as in our factory fires. If the combustion had been perfect no solid carbon could be present except as carbonic oxide or carbonic dioxide, which are gases and invisible. Hence the removal of this matter from the air means not only purification of the air but economy of production, for it must increase the efficiency of the

furnace. To minimise fog we must, therefore, reduce the number of carbon particles in the air, and this is to be done by improving the methods of combustion.

The removal of these carbon particles must also influence health, for everyone knows the distressing effect of fogs on coughs and colds. I have recently spent a few weeks in South Africa. I caught a severe cold in ascending 6,000 feet to the Transvaal. Johannesburg suffers occasionally from a plague of dust. A fine impalpable dust is driven about by the wind, sometimes forming great clouds, and occasionally giving the appearance of fog. There is no real fog. The air is too dry. But this dust percolates every mucous membrane of the body and renders life scarcely worth living for brief spaces. My body for a week or so became a dust-bin, and my handkerchiefs were brown with the dust of this dust-laden, but otherwise charming place.

The proposals to establish a few large power-houses on the river in London to supplant the 70 or 80 scattered electric generating stations that now exist have one great merit; they will abate the nuisance of smoke and introduce more perfect methods of fuel combustion and so reduce fog, for the cheapening of the cost of production of electric energy means the adoption of every known means of economy.

Internal combustion engines where producer gas is sucked in and exploded is another promising field for the enthusiast. They produce no smoke and discharge no particles, but they are limited at present to small engines and are not yet applicable to the great power-houses that are now increasing in all industrial areas.

It is probable that the greatest sinners are the ordinary domestic grates, the most unscientific and inefficient heat producers in existence. Their consideration does not come within the function of this section, but I cannot resist condemning a system which patriotism, conservatism, or sentiment maintains popular, aided by the abundance and cheapness of coal. The supposed cheerfulness of an open fire is proverbial, and there may be some truth in it for it certainly aids ventilation. On the other hand it encourages draughts, and causes the distribution of heat to vary immensely in different parts of the room. I have remedied this last defect by having an open fire at one end of the room and a radiator excited by hot water or by electric currents at the other end. The price of electrical energy is falling so rapidly that the electric radiators will soon become a domestic comfort within the reach of all.

The baneful influence of smoke on health is not confined to inhaled

material particles, it reduces daylight and deprives us of the sun. It deteriorates plant life and it coats every exposed surface with soot, tar, and acids. Mr. Mactear in 1875 stated that 245,000 tons of sulphuric acid were belched forth in London in one year. Dr. Rideal makes out that it is now more than twice as much.

There are many well-known smoke consuming processes. Bituminous coal can be burnt completely so as to emit no smoke. It is only necessary (1) to regulate and heat the air supply to the furnace, (2) to secure and maintain the proper temperature in the furnace, and (3) to control the escaping gaseous products up the chimney. Such arrangements are undoubtedly economical. Crossfield & Sons, of Warrington, have saved 1,000 tons of coal per week by adopting scientific smoke abatement methods. Newnes & Co. and the Cardiff Railway Co. assert that they have saved 25 per cent. of their coal consumption. A firm of brewers in London has saved £3,500 per annum, and I can speak from my own experience that wherever such appliances have been used marked economies have followed. But it must be remembered that chimney, flue, furnace, mechanical stoking, air regulation, preparing, elevating, and conveying fuel, water heating, all lend their weight to the desired consummation, the complete conversion of the potential energy of coal to the kinetic energy of heat and the total elimination of smoke.

There are certain peaceful methods of attaining this goal by gas, oil, and electricity, but we are here to discuss smoke abatement.

The production of smoke is a wasteful, dangerous, and useless barbarism, and I hope this Conference will drive that fact home.

The Smoke Abatement Society prides itself on the number of convictions it has obtained under the Public Health Act of 1891. It would be much more satisfactory if they recorded the number of firms who have adopted scientific measures and shown their economical results. This would excite emulation, a very potent force in commerce and industry. Law is not so effective as simple common sense. Satisfy people that smoke is matter in the wrong place and that money can be saved by its prevention, they will save money. Most people rejoice in doing what they are told they ought not to do; it is the cussedness of human nature.

Legislation is often obstructive, for it excites the love of resistance to enforced action against personal will and party proclivities. People will not adopt smoke consuming systems if they can avoid it simply to comply with supposed parliamentary tyranny, just as certain classes resist the progressive clauses of the last Education Act. It is different when you

touch their pockets, and when you convince them that economy results. Then political objections disappear, and common sense, or in other words, science, reigns supreme.

I think legislation would be looked upon with more favour if "emitting black smoke" were regarded as an occasional exceptional occurrence, and treated as an ordinary nuisance, done without negligence, and which had been provided against by every reasonable precaution as determined by Lord Blackburn's judgment. Sudden fogs, sudden breakdowns, unexpected accidents may cause the steam to lose pressure, and then the engineer in charge has to decide between loss of voltage and presence of smoke.

I should always support the maintenance of voltage, for the loss of voltage would affect a large district and a great number of innocent people, while the presence of smoke might affect one engineer only.

However, there is no excuse for neglecting reasonable precautions.

STOKING AND SMOKE ABATEMENT.

By COMMANDER W. F. CABORNE, C.B., F.R.A.S., F.R.G.S., F.R.Met.Soc.

IT can, I think, be laid down as an axiom that good stoking is the main factor in the prevention of the emission of smoke from furnaces.

In fact it may be broadly asserted that an intelligent and well-trained stoker will often obtain better results from indifferent coal than will a less expert man with superior fuel. In other words, the skilful workman not only avoids committing a smoke nuisance, but at the same time effects a considerable saving of coal, to the benefit of his employers.

I am not overlooking the fact that the quality and nature of the coal used, as well as the design and construction of the boilers, furnaces, etc., have also an important bearing on this question, and form material component parts of it; but what I particularly desire to lay stress upon is the paramount value of the personal equation.

In support of the proposition I will give some extracts from "Reports on the Laws in Force in certain Foreign Countries in regard to the Emission of Smoke from Chimneys," presented to Parliament in February, 1905; the information having been furnished to the Foreign Office by His Majesty's representatives abroad, while the return itself is due to the initial action of the Coal Smoke Abatement Society.

Mr. Richard Seymour, attached to the British Embassy at Vienna, wrote: "In the first place it must be emphasised that the compulsory introduction of technical measures to procure smokeless or almost smokeless fires would only be practicable if thoroughly adequate appliances existed to ensure the desired result. In this connection experience shows that no system hitherto recommended and applied is exempt from serious disadvantages. The best laid furnace requires constant supervision and attention, nor will it burn properly unless carefully tended. There is a well-known saying to the effect that a good stoker is the best consumer of smoke."

Mr. E. Hicks Beach, Third Secretary of the British Embassy at Paris, said: "Choice of fuel, care in stoking furnaces, well-constructed chimneys, may contribute largely to the restriction of smoke, but cannot entirely prevent its emission."

While Mr. Arnold Robertson, Acting Third Secretary of the British Embassy at Berlin, stated that: "In the opinion of the Prussian Government the employment of proper firemen will go far to minimise excessive emissions of smoke."

From the same document one learns that in the Kingdom of Würtemberg the following clause is usually inserted in a licence to construct steam-boilers: "The owner of a steam-boiler is required to see that the fuel is as far as possible entirely consumed, and to endeavour to prevent smoke and soot by using fuel of proper quality and in proper measure, by suitable flues and by careful stoking, and he must further undertake to have such structural and other alterations made as may be from time to time required to attain the object in view."

Mr. Edward Atkinson, President of the Mutual Boiler Insurance Company of Boston, U.S.A., in a report on the suppression of smoke, dated July 18, 1901, said: "Smoky chimneys give evidence of waste of fuel, not because the calorific value of the visible smoke is considerable, but because the existence of the smoke is evidence of bad methods of firing and of incomplete combustion. This may be caused by want of skill in the fireman; by overloading the boilers with work; by insufficient fire-boxes and imperfect settings. The smoke may be suppressed in many cases by closer attention on the part of the firemen. . . . ."

A few months ago the Coal Smoke Abatement Society circulated certain questions among manufacturers and others who had once been offenders against the Smoke Prevention Clauses of the Public Health Act, and had since amended their ways, asking for information as to the means which they had adopted for the prevention of the emission of smoke. As Dr. Rideal is dealing with the replies received, I will only say that, while some of the firms in question had substituted gas-engines and electricity for coal-driven machinery, a considerable percentage of them placed their dependence largely, if not altogether, upon good stoking; and the following quotation from one of the answers may be considered typical of the views expressed by the latter section: "Even when so-called 'smokeless' coal is used, it does not necessarily follow that smokeless combustion takes place, unless care is given to the proper design of the boiler and furnaces, and unless the stoking is carried out with intelligence and care. We exercise great care in the selection of suitable men as stokers, and to a great extent

these men are trained at our works, and they are always under the close inspection of our engineers. The wages paid to the leading stokers are somewhat high as compared with the average wages paid for this work in ordinary factories, but we consider that the extra wages paid to a really competent stoker are easily saved by the economy of fuel which he can effect by securing proper combustion in the furnaces."

Of smoke-consuming inventions, one gentleman wrote: "We have many times tried using bituminous coal with different sorts of smoke-consuming apparatus, but our experiments have never been wholly successful, and I do not believe that the apparatus is in existence that will prevent smoke under all conditions. With nearly all smoke-consumers you are more or less dependent upon careful attention of the stokers."

Another correspondent, speaking of the manner in which his firm was at one time harried by a prominent member of the Coal Smoke Abatement Society, said: "He made it a rather warm corner for us, but his action led to economy, so I must be thankful to him."

It was about thirty years ago that high steam-pressures began to claim the earnest attention of engineers, a pressure up to 50 lbs. per square inch having previously been that generally in vogue; and in the period covered by my own sea-going days, I have known a pressure of less than 30 lbs. per square inch on the boilers of a then modern steamer in good condition.

The varieties of coal used in bygone years were few compared with those now drawn upon; their calorific values were little understood; analysis of their several qualities was seldom made; their evaporative power was rarely ascertained, etc.

The last three decades have witnessed a complete revolution, or perhaps one should rather say evolution, in all these matters.

We now possess huge and delicate boilers, comprising water-tubes, economisers, etc., some of them capable of evaporating from 30,000 to 40,000 pounds of water per hour, and requiring that the utmost amount of care should be exercised in their management in order that the maximum quantity of carbonic acid (CO_2) may be made, that being a condition equivalent to, or almost equivalent to, thorough combustion.

This being the case, the stoker of the present day, if his full value is to be developed, requires to know how to fire efficiently with an almost endless variety of fuel: such as bituminous, semi-bituminous, Welsh, dry Welsh coal, anthracite, bastard anthracite, coke, coke breeze, etc., the fixed carbon in the various descriptions of coal varying from about 50 to 92 per cent., and the resultant ash ranging from 3 to upwards of 20 per cent. Some of these ashes do not make much clinker; others, again,

make heavy, tough clinker. A number of collieries in England, Scotland, and South Wales now wash a considerable portion of their output.

It is also requisite that a thoroughly capable stoker should understand how to burn from 10 to 40 lbs. of coal per square foot of grate-surface per hour with any coal that may be supplied; that he should comprehend how to manipulate his dampers (and weather has great influence upon chimney-draught) so as to save coal and at the same time to keep a sufficient head of steam; that he should know how much air to admit, either by opening or shutting the dampers or cleaning or pricking his fires; that he should be competent to work the feed-pumps and injectors; and, in addition, it is desirable that he should be able to test the flue gases for temperature and also for carbonic acid (which should amount to 15 or 18 per cent.), because, although the stoking may be excellent, these tests may disclose the fact that the flues are letting in air, which is fatal to satisfactory results.

One great difficulty in many large towns, and particularly in London, is the lack of room for the additional boilers required by factories owing to the expansion of their trade, as this necessitates the burning of more coal per square foot of grate-surface per hour under the boilers already installed, and it appears to be not unusual for 40 lbs. of coal, or even more, to be so consumed per square foot of grate-surface per hour; whereas, in normal cases, 20 lbs. of coal would give higher proportional efficiency.

It cannot be too strongly impressed that the forcing of inadequate boiler power is one of the prolific causes of factory-smoke.

The saving of fuel which a good stoker can effect is an argument for his being well paid, and some firms reward their stokers with a bonus, calculated upon the value of the amount of coal it is estimated they have saved. This possesses another advantage, that the stoker will soon complain to his employer in the event of the coal-merchant endeavouring to palm off upon him an inferior coal.

Now, the proper training of stokers has been strangely neglected, especially in connection with men employed in small works.

In the case of large installations of steam-boilers, trained men are frequently engaged to supervise the other stokers; but such qualified persons are difficult to obtain.

This being so, such devices as mechanical stokers are brought into play, but it does not seem probable that they will supersede hand-firing to any great extent, owing to the drawback of wear and tear, and also to the certainty that moving machinery exposed to the intense heat of furnaces is specially apt to get out of order.

It is said that mechanical stokers cannot efficiently handle Welsh dry coal or anthracite, and, if such is the case, it is a serious disability in their use, at any rate as regards London, as those descriptions of coal are almost free from smoke, and can be delivered here sea-borne at about the same price as English and Scotch coal.

I prefer to pin my faith to the properly trained human element, and particularly in the case of small installations, which form the preponderating number. However, in the case of large installations, I am aware that it is occasionally argued that the cost involved by manual labour outbalances the advantages obtained thereby.

Nothing has hitherto been said by me about induced draught, but it would seem that the time is not far distant when huge chimneys will give place to small ones and suction-fans, and the waste gases will be used to heat the air supplied through the ash-pits; and that would naturally tend to reduce smoke-nuisance, as by its introduction perfect combustion would be more nearly obtained.

We have seen what should be the qualifications of a thoroughly competent stoker, and we are aware how far short he frequently falls of the ideal we have set before us; it may not be inopportune to glance at the manner in which different classes of stokers are manufactured.

In the case of the Royal Navy, the young men enlisted in the stoker branch of the Service are sent to a harbour depot-ship, where they are instructed by engine-room petty officers in the handling of shovel, slice, and pricker, and in the duties and general routine of the stoke-hold, and they afterwards perform duty on board instructional torpedo-boat destroyers and torpedo-boats, being the whole time under the strict supervision of capable teachers. The course of instruction, the exigencies of the Service permitting, usually occupies some nine months, and then the full-fledged neophyte is drafted to a sea-going ship.

In the case of the Mercantile Marine, as a rule no real preliminary training takes place, the man originally engaged as a coal-trimmer, after some little experience in that capacity, succeeding in due course to the higher rating of fireman or stoker.

In this country there seems not to be any provision made for training of stokers for land-service.

I understand that some little attention is directed towards this question in the United States of America.

The Prussian Government in 1902 introduced a course of instruction for stokers, and in the Budget allocated £2,000 per annum for this purpose. The motives which induced the Government to ask for this grant are put

forward as follows: "The preliminary condition for the prevention of excessive emissions of smoke is, as experience has shown, the instruction of capable firemen. This would also have the advantage of leading to better insurance against boiler-explosions and to economy. In view of the general State interests which are here in question, and of the proven failure and insufficiency of efforts on the part of persons interested, it is desirable that the State should take the proper steps for such instruction to be given. By way of experiment, and for at least two consecutive years, itinerant courses of instruction will be instituted for firemen and engineers. The instruction will be given once a fortnight by academically-educated instructors paid by the State, according to a uniform system. . . . . In addition to the instructor a capable superintendent will give practical lessons. . . . . . In addition to this the Boiler Supervision Societies will employ firemen instructors, who will give the necessary lessons at the boiler and the engine to the firemen and engineers who are employed in country districts less developed industrially, and who cannot avail themselves of the courses of instruction that have been instituted."

In a document setting forth the principles according to which measures are to be taken in Prussian Stationary State Furnaces for the prevention of excessive emissions of smoke, it is directed that: "In order to avoid the annoyance and damage which may be caused by smoke from stationary furnaces, care should be taken in all works under State control that the emission of black, thick, and continuous smoke be avoided in the first instance by expert management of the fires, proper supervision over the firemen, and careful selection of fuel.

"The emission is to be regarded as continuous if black, impenetrable smoke proceeds from a chimney for more than five minutes without interruption.

"As far as is in any way feasible, care should be taken that only such persons as have satisfactorily managed furnaces for a considerable time shall be employed as independent firemen. If these persons have not gone through a satisfactory course at a fireman's school, opportunity should be given them as far as possible to attend one.

"The authorities who have furnaces under their superintendence should, moreover, see that firemen are instructed as to the cause of the emission of smoke, and that sufficient control is exercised over them.

"In choosing fuel the guiding principle should not, as a rule, be that the emission of smoke is to be prevented by the acquirement of expensive kinds of coal, or of coal that gives out little smoke without particular care, or by replacing coal by coke (except when the latter cannot be

dispensed with on account of the nature or object of the furnace); but rather that the fuel is to be obtained which is generally used at the works, even if difficulties in the way of preventing smoke are thereby incurred.

"If excessive emissions of smoke cannot be sufficiently prevented by careful management of the fires, supervision over the firemen, nor by the selection of fuel, without considerable increase in the cost of fire, a few furnaces should be provided with special tried appliances for the prevention of smoke in all places where this may be desirable in view of the situation of the works."

I am of opinion that, as regards the efficient training of stokers, we might well adopt some plan analogous to that inaugurated by the Prussian Government in 1902. However, I would substitute municipalities and county councils for the State, the more so that those bodies have already many facilities for the instruction and examination of candidates desirous of obtaining certificates of proficiency.

If instructional courses for stokers were instituted, and if employers would give a preference to those persons who had been properly trained and could produce documentary evidence of the fact, the result would go far towards mitigating the smoke-nuisance, and would, at the same time, effect an enormous saving of money now constantly wasted through the imperfect combustion of coal.

REPORT BASED UPON RETURNS FURNISHED BY MANUFACTURERS WHO HAVE SUCCEEDED IN SECURING

THE ABATEMENT OF SMOKE IN FACTORIES.

By SAMUEL RIDEAL, D.Sc.Lond., F.I.C. (F.R.SAN.I.)

INQUIRIES, in the form of a circular letter issued by the Coal Smoke Abatement Society, were addressed in February, 1905, to 63 firms, in respect of whose manufactories or chimneys no smoke-nuisances had been observed for six months. For form of inquiries see schedule appended.

Of the 42 firms which replied, 38 supplied information and the other four invited a visit from the Society's officials, when any information would be supplied. Of the 38 firms which supplied information, 32 agree to the publication of their methods, while only 6 object. Three of the 38 have substituted *Gas Engines* for steam plant, leaving for further analysis the information supplied by the remaining 35 firms.

Thirteen firms mainly ascribe their success in preventing the emission of smoke, to *careful stoking.*

The following is a list of the various fuels used, supplied by the 35 firms :—

17 Firms burn Welsh coal only.
1 Firm burns Welsh coal and coke.
2 Firms burn Welsh coal and hard steam coal.
1 Firm burns Welsh coal and bituminous nuts.
1 ,, ,, Welsh coal and anthracite.
4 Firms burn anthracite only.
1 Firm burns anthracite and hard steam coal.
1 ,, ,, anthracite, coke breeze and small house coal.
4 Firms burn hard steam coal only.
1 Firm burns "good small coal."
1 ,, ,, bituminous coal.
1 ,, ,, coke.

Of mechanical devices for economising fuel, 18 firms supply the following information of the results of their experiments:—

		If economical.
1	British Fuel Economiser.	Yes.
2	Martin's Patent Smoke Consuming Door.	„
1	Perforated Furnace Doors.	„ (fairly.)
1	Richard's Patent for Forced Draught. ...	„
1	Special Mechanical Device.	„
1	Tubular Fire Bars, supplying heated air to back of bridge	„
1	Edwin Coles' Furnace Door. Cuddy's Tubular Bars.	Not stated.
1	Johnson's Economiser and Smoke Consumer	Slight saving.
2	Chain Grate Stoker. (One, not successful with Electricity Generating Stations, the other not running long enough to form an opinion.)	
1	Induced Draught	Yes.
1	Steam Blower	No.
1	Automatic Air Louvres	Very.
1	Meldrum's Forced Draught and smoke Preventer	„
1	Meldrum's Forced Draught, do., do.	Yes.
1	Patent Venetian Fire Bars	Effective but extravagant of coal.
1	Venetian Rocking Furnace	Saves 10 °/ₒ of fuel.

Two firms which have tried various mechanical devices, emphatically disclaim any benefit derived from them, and support the evidence of other firms in favour of careful stoking.

Two firms ascribe success to the high chimney-shaft giving an excellent draught, and one of them, in addition, to the fact that its boilers have been "set" with large flues.

One firm is abandoning mechanical devices in connection with boilers and steam engines, and is replacing them by electrical machinery, in the hope of effecting an economy.

It will be seen from these replies that though not denying the efficacy of many mechanical devices, yet the general consensus of opinion favours skilled and careful stoking as of the first importance.

QUESTIONS.

1. What description of fuel do you burn, Welsh, bituminous or coke?
2. What description of boiler do you use?
3. What mechanical device (if any) have you for preventing the issue of smoke from your chimneys?
4. Do you find the use of such apparatus or the other steps you have taken economical or otherwise?
5. Do you wish your communication to be treated as confidential?
6. Any other information or remarks?

Name of Firm . . . .

Address . . . .

THE ARTIFICIAL PRODUCTION OF PERSISTENT FOG.

By The Hon. ROLLO RUSSELL, M.A., F.R.Met.Soc. (F.R.SAN.I.)

STANDING on the summit of the Malvern Hills early on a fine frosty morning, clear on the heights and with stratus at a much lower temperature on the plain up to about 200 ft., one may see here and there a column of factory-smoke rising for a little space above the fogbank and recoiling into the cold cloud from which it had for a moment emerged. The smoke, warm on its projection into the outer air, and lifted by hot gases, is able to penetrate the stratus, but is quickly cooled by contact with it and by radiation into the sky, and so takes its place in the recumbent horizontal cloud, condensing vapour upon itself and slowly sinking.

Soon, however, the sun pours his beams on the surface and evaporates the droplets of water, which gain more heat than they radiate, and the fog continues to dissipate from above downwards. In two or three hours it is gone, and the air near the ground becomes warmer than the layer above it, and rises. The smoke from the few factory-chimneys is incompetent to arrest appreciably the natural process of evaporation under the thermal work of the sun's rays.

Now take another situation in similar weather, and scan from Hampstead Heath or the Crystal Palace Water Tower the expanse over London. From 6.30 a.m. onwards a huge evolution of dark smoke proceeds, not only from hundreds of factory-chimneys, but from hundreds of thousands of kitchens. Smoke penetrates the fog through and through, it enters particle by particle into contact with existing spherules of water, and, owing to radiation into space, adds to the amount and darkness of the stratum by condensing upon itself the available vapour of the saturated mass. Sulphurous gases, hydrocarbons, and vapour resulting from combustion contribute to the mess hatched out of the cold cauldron of the London Basin, all conspiring, before the sun rises, to defeat his majestic rule. At sunrise the whole London area, cold, becalmed, shrouded,

has, up to 200 ft. or higher, a cloud of water-particles and smoke-particles copiously radiating heat to the stars and removing it from the air.

The growing sun-power of the early hours may succeed here and there in evaporating an unassociated water-globule; it fails to raise or carry off a smoke-particle, or a combined smoke and water particle, in which either the soot tenaciously retains the moisture, or, possibly in some cases, the fog-globule protects itself with an oily skin. The water-particles continue competent to radiate while protected against dissolution. They even fail for a long time to respond to the thermal orchestra which beats upon them, and which would call them to break up and stream into a higher region, for they radiate strongly upwards while defended by volumes of obstructive smoke eastwards from the nearly horizontal rays, already weakened by passage through many miles of dusty air near the dewpoint.

Sometimes the power of the sun, even in winter, may avail to dissipate a real London fog, but in typical radiation weather, with calm and pertinacious cold, the clearing of central London is rare; and with a very slight breeze, the clearing of suburbs to leeward is rarer still. The creation and maintenance of a London fog are the result of the inability of the lower air to rise. It is only during the conditions which give rise to radiation fogs that both wind and vertical circulation are inhibited, and therefore it is only on these occasions that the air in the streets becomes dense with smoke. We are cut off from the circulation of the great atmosphere.

The continual rapid growth of streets and houses in the area around the London of 1860 has had two effects on London fogs, one favourable to their augmentation, the other (and, I think, the more potent) favourable to their diminution. While the new houses add to the actual amount of smoke in the air, the increase to a very important degree of a dried and warmed surface, deprived of grass, has two consequences which work against the production of dense fogs. First, the formation of ground-fog is signally hindered. In old days, I always found the public parks to be the best breeding-grounds of dense, natural, ground fogs; and these fogs overflowing into the streets, would there somewhat diminish through contact with warmer surfaces and through obstructed radiation towards the sky. Warmed houses are in themselves unfavourable to stratus. Thus suburban London, with wide areas of warm dry surfaces, has to a great extent saved central London from the fogs which grew from the open grassy surfaces of hills and marshes which formerly surrounded us. Secondly, when fogs are formed, they have acquired through their enormity, or rather, through the immensely greater quantity of heat which they contain, the faculty of automatically setting in motion the machinery for their removal.

The amount of heat now liberated by the combustion of coal and gas within Central and Greater London enables it to accomplish important effects in circulation. The temperature of Central London on cold mornings is frequently from 4 to 8 degrees higher than the temperature of places ten miles outside in every direction. Consequently, a regular upflow of air, gases, smoke, and combustion-products generally takes place on every calm morning without fog, and on many calm mornings with fog; in fact, one may, I think, safely say on nearly every calm and fair morning, except with ground-fog or very low fog. Then circulation and horizontal inflow from the country follow. And, as we have seen, dense ground-fog is of necessity becoming increasingly rare at nights, owing to the spread of warm dry surfaces round the town. In the daytime, even twenty-five years ago, I noted a gentle inflowing current round Central London in a dense fog. Thus we find that the conditions favourable to severe continuous fogs in London have become less and less likely to occur, and that the dark radiating stratum of fog and smoke is frequently now raised some hundreds of feet above the streets. With a slight breeze this dirty cloud is carried to the country and descends nearly to the ground at a distance of ten to thirty miles, often actually increasing in density as it cools.

Yet we must remember that a spell of calm radiation weather, with prevailing great cold and fog in the country, is still competent to produce very dense, persistent, dark fogs in London, and that these fogs may be destructive to human life. A certain intensity of radiation, depending on the dryness of the upper air, and a certain depth of low fog, depending on the character of a lower current and the degree of cooling to which it has been subject, will enable the smoke retained near the ground to shut out all sunshine, and to produce a sooty stratum noxious almost to the point of suffocation.

Conditions have not occurred for some years past which allowed the long maintenance of the worst, the most life-endangering fogs, but they are sure to come soon. The most disastrous in my experience (and I have pursued some of the very worst) have belonged to a period distinguished by brilliant weather in the country, or else to persistent radiation-fogs with very low temperature at night. The darkest days in London have been the brightest outside the town-influence. Two out of three of the darkest, when the blackness of night was reached, were on Sunday and Christmas Day, so that factories are proved not to be the chief offenders. The multiplication of dinners explains the excess of fog on Sundays in winter.

Wet fogs, due to a moist general air and to conflict of currents near the ground, and not to radiation, are invariably less dense in London than in the country. When the trees are dripping continuously, London usually gives to the incomer from the country a pleasant surprise. With a cloud-canopy overhead the smoke is not retained near the ground and does not gather moisture: the air over the town is warmed and dried above the dewpoint.

It is radiation which above all maintains a particular London fog. In several previous papers I have recorded facts showing that fog and haze are very largely dependent on different currents in the atmosphere. Increasing cold, calm, and radiation, with a difference of winds, shown by high and low clouds, are signs which ought to be taken as warnings that fog may easily develop. Conversely, an approximation of currents leads to the dispersion of fog. So does an extension not only of visible cloud but of a moisture-laden air through the upper strata, between the middle cloud and the upper cirrus level.

Observations made in Baden some years ago showed that during anticyclones the air at a high level is unusually transparent. And a large number of automatic balloon observations, recently classified, testify to the uncommon dryness and warmth of the upper strata over areas of high pressure. Conversely, the high air over cyclones is moist and cold, capable therefore of reflecting the warmth of the earth, and preventing rapid loss by terrestrial radiation. Hence transparency near the ground.

It has been suggested that, since mere combustion results in the projection of a very large volume of dust-laden gases into the air of London, and since vapour-precipitation takes place only on solid particles, many of which are microscopic, therefore we shall be subject in London to an excess of fog, whatever the fuel which may be burnt. It has been argued plausibly that the very fine invisible dust produced in countless millions from every gas-jet, will be competent, no less than the smoke-particles from our kitchen-chimneys, to maintain the excess of London fogs.

Now I do not know that theoretically we have the data on which to disprove this proposition. Fine, invisible dust has been shown in the laboratory to be capable of producing fog by precipitation of vapour on cooling. The dustless bell-jar remains free from fog.

On the other hand, we have the overwhelming evidence of experiments on a large scale against it: the evidence of the districts of anthracite coal, of towns where wood is burnt, of towns where oil or oil-gas is burnt, of towns where charcoal and gas are burnt, that no excess of fog affects these places. In an excellent test case, that of Pittsburg, coal-smoke

caused much darkness and fog-cloud. Then coal was superseded by oil-gas, which freed the city from obscuration. Then, after some years, I think, coal was largely used again, and dark fogs recurred.

The mistake of imagining artificial fine dust to be a fog-producer like coal-smoke, has arisen probably from leaving out of consideration the fact that the lower air has nearly always sufficient natural fine dust to allow of vapour-precipitation in favourable conditions; so that a great excess of fine artificial dust is not required for the formation of a stratus cloud. Fog forms wherever there is unusual radiation, calm or light airs of different temperature, saturation, and increasing cold. It finds points of condensation enough in the neighbourhood of the ground; and, even at great heights, clouds follow a small reduction of temperature or contact with a colder current.

But the smoke of sea-coal has additional qualities which enable it to gather and retain moisture, and, where very abundant, to prevent the warming of the earth while defending its own mass from the sun's rays. Lamp-black or soot is the most effective of radiators and absorbers of heat. And we have above all to remember that coal-smoke makes a fog by itself, as in a room, while gas and clear-burning wood make no visible fog.

A dense smoky mist would be produced by the mere conditions which allow the natural ground fog to exist, even if that fog were removed. The smoke is caught and retained by the air over large towns as completely as if the town were covered by a roof of the height of the stratus, one to two or three hundred feet. Imagine a room twenty feet square and two hundred feet high, into which a coal fire poured thick smoke for an hour. At the end of the hour the air throughout this tower would be choking thick with smoky particles; there would be a small London fog without the moisture, and a brilliant light in the roof would hardly pierce it. No doubt the proportion of smoke to air in the open spaces and least thickly inhabited parts is less than in the above example. But the height of a fog is often less than two hundred feet, and the number of hours of thick smoke effusion is more than one. Nearly the whole of the products of chimneys, after two or three hours of emission, are sometimes concentrated within a hundred feet of the ground. If the ground has been very greatly chilled by previous frost, the mass of lower air, moisture, and smoke clings tenaciously, like water under oil, to the neighbourhood of the earth, so that beneath a clear sky the combined heat of the sun and of the combustion products of thousands of tons of coal within London may be incompetent to disperse the fog.

When there is no fog at all, but a clear sky before sunrise with frost,

as, for instance, on Nov. 21st, 1905, the smoke may remain for some hours in the streets and up to a moderate height, making the sun invisible and the air unpleasant to breathe. With a dense fog, the smoke is more concentrated, and the effects more severe.

In one of the great fogs of 1880, the depth of the stratum (formed by a south wind moving over frozen ground) was only about thirty feet in Belgravia and Knightsbridge, and the density was such that drivers could not see half across the road. This was a rare case; the fog was white owing to the escape of the smoke into the clear, warm, upper air. In a similar fog early one April at Portsmouth, extending to the Isle of Wight, the topmasts of steamers were in sunshine, but the captains refused to make the passage during the whole morning.

These are clearly not fogs artificially generated or prolonged, nor can they be reduced. But they are naturally not of long duration.

Dark fogs of long duration are preventable simply by the reduction of the visible solid impurities cast into the air by the process of combustion. Good results are obtainable by the use of anthracite-coal, gas, or wood, by the careful combustion of ordinary coal (that is, by good stoking in proper grates and furnaces), and by the substitution of radiators or hot-water pipes for separate fires in large houses. There can be no question that this last system, even now, in the big hotels and clubs, saves a great deal of trouble and dirt, and adds greatly to comfort by abolishing chilly rooms with their sources of air-pollution. But many of the kitchens of hotels and clubs are among the worst offenders in the production of black smoke.

The chief problem for immediate practical purposes is the preservation of the cheerful open fire of sitting-rooms, including many kitchens, without the production of much smoke. Improvements in grates and a more scientific feeding of fires by housewives and housemaids would lessen the nuisance considerably; but scientific training seems still to be a long way off from the purview of the directors of education. At this moment, however, I see a programme of the Education Committee of the Surrey County Council which opens up a vista of practical training for domestic utility, with a proper regard for personal and general welfare. Although civilization has existed for thousands of years, we of Western Europe have hitherto almost wholly neglected the science of the amenity of daily life, and scarcely a child is taught how to feed economically, and therefore with most benefit, either its own body or a coal-fire. Regard for neighbours and for the whole community, as well as for the productive work of the family, would counteract the present wastefulness which we see in all directions, and even among the poor.

A combination of the close stove and open fire has great advantages. The close stove warms a room at least one-sixth more per pound of coal than the open fire of the best construction, and is capable of burning anthracite easily, a fuel which gives one-eighth more heat than ordinary house-coal.

Possibly the more general introduction of heating gas may precede the extension of house-science to the schools. Gas has the advantage over coal of being always obtainable without trouble, and without the heavy traffic of coal-wagons, which add to the blocking and wearing of streets. More general cooking by gas is already beginning to purify the London air from the domestic side, and the legally enforced improvement in factory smoke consumption has had a decided effect.

It has not been sufficiently realized that by far the greatest volume of dense smoke is produced by the ordinary way of lighting fires, during the first hour of ignition. If the coal could be made to kindle without dense smoke, London fogs would be deprived of their worst qualities. At forty miles distance from London the smoke brought to the country by the wind is much more dense in the first hour of arrival than later. It represents the hour of kindling.

The additional sun-warmth obtainable by the diminution of dark smoke may be inferred from the statistics which show that in winter London has less than half the bright sunshine of inland stations, and little more than one-third of the sunshine of stations on the south coast.

The average daily consumption of coal in London on cold days in winter is about 50,000 tons. We may take 10,000 tons off this amount to allow for the heat converted into other forms of energy.

The experiments of Fabre and Silbermann showed that the consumption of 1 lb. of coal produces heat sufficient to raise nearly 8,000 lbs. of water 1° C., or, I suppose, roughly, to raise 80 lbs. of water from the freezing to the boiling point. The burning of 40,000 tons on a winter day in London is thus sufficient to heat 3,200,000 tons of water from 0° to 100° C. Thus a lake 1 ft. deep and with sides $1\frac{3}{4}$ miles long, occupying 2,500 acres, would be heated from 0° to 100° C.

Otherwise stated, and more to the purpose, 1 lb. of coal would heat 396,000 cubic feet of air at the ordinary temperature 1° C.; 1 ton of coal would heat 887,488,000 cubic feet 1° C.; and 40,000 tons would heat 35,499,520,000,000 cubic feet 1° C. Roughly, this quantity of air warmed 1° C., or 1·8° F., occupies a space equal to that contained in a layer 1 ft. deep and 1,140 miles square, or equal to a layer 10,000 ft. deep and eleven miles in the side square. Or a layer 5,000 feet deep and eleven

miles square, that is 121 square miles, would be raised 2° C. or 3·6 F. This area, I think, nearly corresponds with the area of London. Thus, during one hour, about $\frac{1}{16}$th of the time during which fires are alight, a layer of 312 ft. deep would be heated 2° C. Half of this rise may be deducted for the heat used in warming the interior of buildings, and in other ways, so that we may safely take 150 ft. as the depth of the layer which would be heated 2° C. in one hour. But the effect would really be greater, on account of the permanently higher temperature of the house- and ground-surfaces in London, probably at least 3°, in winter months, above the ground surface temperature in the country. A comparison of the temperature at Old Street with the temperatures in the neighbouring country, as recorded in the Meteorological Tables for the last three months of 1904, shows an excess of 2 to 4 or even 5 degrees on cold mornings at 9 a.m. Moreover, the very large emission of vapour in combustion increases the lightness of the lower air.

Owing to the unequal distribution of houses and chimneys, and to large open spaces, the probable actual effect in moderate fogs would be that gentle up-draught columns of air and smoke would form over many separate places, in the manner of the invisible columns of smoke which create cumulus clouds. Thus part of the fog would often be carried up and away.

In dense, low fogs, with very rapid radiation to a clear sky, the loss of heat by the smoke and warmed air would be too quick to allow of the ascent of quantities of warmed air, and the fog would remain dense in a calm atmosphere throughout the day. When the layer of clear air above the fog is five to eight degrees warmer than the stratus, as it often is, there is obviously no ascensional energy available to remove the fog.

In some cases, with a layer of cold air, or a very low stationary cloud a few hundred feet above us, the smoke and warmed air would ascend to a level somewhat higher than the top of St. Paul's, and would then be caught by the cold stratum, causing great darkness over the city. This condition is becoming more frequent in London.

We must still expect the maxima of cold fogs to coincide with the maxima of smoke-retention, involving danger to health and life, although the frequency of moderate smoky fogs seems likely to diminish.

The most important immediate problem requiring solution is the easy kindling of fires with little smoke and careful stoking, and economy in fuel of the right sort.

ON THE DESTRUCTIVE EFFECT OF SMOKE IN RELATION TO PLANT LIFE.

By ARTHUR RIGG,
Member of Council, Royal Botanic Society of London.

THE joint Committee of the Coal Smoke Abatement Society and The Royal Sanitary Institute, having requested that some representative of the Royal Botanic Society should read a paper at the forthcoming Conference on the above subject, the Council of the Royal Botanic Society have requested me to perform this part, and I trust to be able to add something of interest to your proceedings.

The subject arose out of remarks in the *Westminster Gazette* on the evil consequences of black smoke to the plants belonging to the Royal Botanic Society. It has, however, been again and again before the Society, and no further back than 1880 Mr. Sowerby says: "Plants cultivated in London suffer at all times and seasons more or less from the dull atmosphere, charged as it is with smoke, and the unprecedented amount (in January, 1880) and duration of soot-charged fog which during many consecutive days hung over the Gardens, prevented the sun's light from reaching the plants, and thus retarded their healthy development. In some cases flower buds have fallen, without coming to maturity; in others unnatural and sickly growth has been the result, and this especially at the greenhouses, the lower natural temperature of the open garden keeping the plants and trees generally in a state of sleep or rest, in which the action of light is not so essential to their vitality."

So far as London is concerned, there seems to have been no appreciable improvement or reduction in the number of its fogs, or their density, during the 25 years since that complaint was written, and the evergreens, with other plants, are still crusted as thickly as ever with a black slimy product which comes down as fog. So damaging is this mud to the plants, that it becomes necessary to keep washing their leaves, and it may be taken as a general rule that a London garden costs twice as much as a

country garden of the same size, and this is entirely due to fogs and their constant companion smoke. Indeed, it is noticeable that West End gardens lose much of their due amount of sunshine owing to the pall of smoke (even when there is no fog) that sunlight cannot penetrate, until high noon has passed, and the afternoons in West End gardens get far the largest amount of life-giving sunlight.

In considering the evil effects of coal-gas, when burnt, upon the life of plants, and no doubt of animals also, it should be remembered that the carbon produced by imperfect combustion does no direct or poisonous harm, but it closes up the pores of the leaves and prevents the performance of their proper functions.

As there is much sulphuric acid in the substance of the fog, it follows that a poisonous action takes place, whereby plants are greatly injured: it is, therefore, very desirable that there should occasionally be a good top dressing of the waste plaster of houses and ceilings, being pulled down, or lime where this cannot be got. This applies to window-box gardens, and to gardens of every size. Those plants which flower near the ground, such as pansies, suffer most from the poisonous surface of the ground, and no plants can be found which are in any way the better for the conditions under which they have to grow in a London garden.

In order to get some idea of the amount of smoke or other items which fall upon the leaves of an evergreen plant (the aucuba), a quantity has been gathered and carefully washed. The difference in appearance of washed and unwashed leaves shows the extent of this evil, and it is no wonder that such a deposit damages the plants that carry on a precarious existence in a London garden. The general consistency of the mud-laden water approximates if it does not exceed that of ink.

In order to learn which plants or trees can live or cannot live in London, as compared with a different climate, namely, that of his estate in Ireland, Mr. Marlay has been making, during many years past, a series of experiments, and the results he has most kindly supplied to the author, who has thus been enabled to publish an extremely interesting comparison. It is curious to note that some plants, as for example the white oak (Quercus alba), will flourish in Regent's Park better than in Ireland, where it enjoys apparently the finest conditions.

It must be remembered that London has variations of climate and more than one soil, and that fogs, into which soot and sulphur largely enter, are prevalent during a great part of the year. Of trees generally, especially deciduous ones, such as the plane, several forms of acer, poplar and birch, will live fairly well in London atmosphere. The

scarlet oak, introduced by Mr. Marlay, has surprised him by its success up to the present.

In regard to common wild flowers, we must not expect to grow these with the same amount of success as we can do in a purer air.

Most evergreen shrubs are very doubtful, and the pine tribe may be given up. Some evergreens will thrive well for a certain time, the aucuba and broad-leaved holly being the best; others will struggle on like the yew and box, for varying periods, but are of no use except in carefully tended gardens.

Fruit-trees might be tried in London on a more extended scale than at present. The experimental garden belonging to the Royal Botanic Society shows very interesting examples of vegetable and fruit growth.

In conclusion, it can be taken as a general rule that all trees or plants with smooth leaves can better resist the action of fogs than those with rough or hairy leaves, such as the foxglove, salvia, and common primrose. These and others of their class suffer the most injury.

So far as plants under glass are concerned, similar conditions prevail, affecting such plants as, for instance, the Chinese primula and cineraria.

In all cases, however, it is necessary to keep the glass clean by washing after the occurrence of fog.

AIMS AND WORK OF THE HAMBURG SMOKE ABATEMENT SOCIETY.

By JOHN B. C. KERSHAW, F.I.C.

NEARLY everyone agrees that smoke means loss of money both to the individual producing it and to the individual whose house, lands, possessions, or person are damaged and blackened by its later descent in the form of smuts, sulphurous vapour, and black fog. There is, consequently, no need to discuss the health or economic side of the smoke problem. What we have gathered here to discuss is the more practical and useful question, to what extent is smoke-abatement possible *now*, both as regards the manufacturing and domestic use of coal? To-day we deal with the subject of *Factory and Trade Smoke*. I am not exaggerating when I state that four-fifths of this is produced by the unscientific conditions under which coal is used in the furnaces of boilers and other heating appliances.

The recently published Report of the Royal Commission upon our coal-supplies, contained the startling statement that of the 150 million tons of coal used annually in this country, an economy of from 40 to 60 million tons, or over 33 per cent., was possible by greater attention to the scientific principles of fuel-combustion. The Commissioners also stated that about 52 millions of tons of coal were used annually for steam-raising purposes, and that the average consumption per h.-p. hr. was about 5 lbs. When one compares with this figure the actually recorded consumption of 1·3 lbs.* per h.-p. hr. for marine engines, one sees what an enormous waste of fuel is now occurring, and what scope there is for the organized attempt now being made to obtain a more scientific use of fuel in our manufacturing industries. This paper will deal with a practical branch of the subject:—namely, the methods of voluntary supervision and control adopted in Hamburg for obtaining greater efficiency and less smoke from the factory-boiler installations in that city.

It is somewhat striking that this example of what can be achieved by voluntary effort, should come to us from Germany, the land of bureaucracy

* SS. Saxonia trials in 1902.

and State control. The *Hamburg Verein für Feuerungs-betrieb und Rauch-bekämpfung* is, however, an entirely voluntary organization of steam-users, and its members are only bound together by the common desire to obtain greater efficiency and less smoke from their steam-raising plant. The Society has now been in existence three and a quarter years, and the following account of its organization, aims and work is drawn from an explanatory pamphlet and from the two annual reports which have been issued since its inauguration in October, 1902.

The work of the Society is controlled by a committee of six to nine members, elected annually. The technical and scientific work is undertaken by the staff of experts retained by the Society for this special work. At the date of the last report this staff consisted of a chief engineer, two assistant engineers, two instructors for firemen, and one clerk, while for special steam-raising and other trials, three additional assistants had also been employed. The chief engineer attends the committee meetings and takes part in the discussions relating to the work of the Society. The funds of the Society are drawn from three sources:—From the annual subscriptions of its members; from payment for special work and reports for its members; from payments for outside work.

The Society is thus entirely self-supporting, and its success is dependent upon the value of the return it makes to its members for their contributions and fees. It is therefore gratifying to note that the membership shows steady growth. Starting with a few members in October, 1902, the register contained 60 firms and 249 boilers at the end of September, 1903, and fifteen months later these had increased to 115 firms and 351 boilers. The report for the year 1905 is not yet published, but I am informed by the chief engineer that the membership is now 150, with 420 boilers under their control.

The objects of the Society, as set forth in the rules, are the attainment of the highest possible efficiency from the heating and boiler plants of its members, with the least possible emission of smoke. To this end, regular examination of these plants and of the methods of working them is undertaken by the expert staff of the Society, and suggestions are made for improvements when such are required. The education and control of the firemen in the proper performance of their duties, are also undertaken by the fireman-instructors on the staff of the Society. Comparative tests of fuel, and tests of smoke-prevention and other appliances of a similar character, are also carried out by the expert staff, and the results are circulated amongst the members of the Society.

Members of the Society can demand that their boiler or heating plant

shall be regularly inspected, and that its working shall be tested and reported on, at least three times a year. They have also the right to consult the chief engineer of the Society regarding improvements and alterations in the design and working of their plant.

They on their side are bound to allow the chief engineer and other members of his staff free access to their heating and boiler plant at all times, and are bound to make the necessary provisions for conducting the tests. They are also required to carry out the suggestions made for improving the efficiency of the plant, especially as regards the *abatement of smoke*, and to submit to the chief engineer all plans for extension of the plant, or for change in the methods of work.

Each boiler or heating plant, when brought under the control of the expert staff of the Society, is tested at the earliest possible date, and a written report upon the results of the examination is submitted to the owner. Should the firing have proved inefficient, one of the firemen instructors is sent to the works to give practical instruction to the firemen employed there, and tests of the plant are made at intervals until this fault is remedied. Defects in design are similarly dealt with.

The annual subscription to the Society for members without any boiler or heating plant, is 20 marks (£1). Members having boilers or furnaces which they desire to place under the control of the experts of the Society, pay a further 20 marks annually for each boiler or furnace.

The extra charges for tests and reports are based upon the time spent upon them and the number of experts employed. Engineers are charged for at the rate of 20 marks per day, and firemen-instructors at 5 marks per day. Special reports upon patented appliances are charged for at the customary rates; members receive a special discount of 30 per cent. on these, as compared with outsiders.

Turning to the work of the Society as set forth in the two voluminous reports which have been issued, one finds that the greatest stress is laid upon the improved efficiency obtained by the instruction of firemen in the proper performance of their duties. This corroborates the view held by many authorities in this country, that improper methods of firing are largely responsible for the smoke-problem. Up to October 1st, 1903, 120 firemen had been specially trained by the officers of the Society, and by December, 1904, this total had been increased to 300. As evidence of the loss in efficiency of steam-raising plants, due to this one cause alone, the following figures are given in the earlier report:—

Thermal efficiency, with the regular but untrained stokers	66·6 per cent.
Thermal efficiency of same plant, with trained stokers ...	72·7 ,,

In the plant where these tests were made, this loss of 6·1 per cent. in the fuel-efficiency represented a loss of 34s. per day, or £10 per week of 144 hours. In another test the loss due to the use of untrained stokers rose to 16·1 per cent., the thermal efficiency being increased from 66·8 per cent. to 82·9 per cent., by mere change of the firemen working the plant.

In this connection the engineer of the Hamburg Society wisely emphasises the fact that the attempt at *smoke-abatement* by untrained stokers, without scientific supervision, generally ends in failure; for their plan is simply to allow air in enormous excess to flow through the furnaces, which means great losses due to the heat passing away up the chimney, and high fuel-costs per pound of water evaporated. The highest tests given in these reports show heat losses from this cause amounting to 27·4 per cent., or over one-fourth of the heat-value of the fuel burnt.

The other branch of the Society's work (namely, alteration in the design and methods of working of the plants under their charge) is also dealt with in these two reports, and the following shows the improvements obtained by the systematic and scientific control inaugurated by the Society, in place of the haphazard and rule-of-thumb methods which had preceded this, in the boiler-plants dealt with:—

		Heat Loss in Chimney Gases.
Plant No. 1, consisting of five Lancashire boilers	First test	25·6 per cent.
	Second "	16·6 "
	Third "	19·3 "
	Fourth "	18·0 "

The saving here represented 11·9 per cent. on the fuel actually used.

Plant No. 2, consisting of two Lancashire boilers with inclined underfeed stokers	First test	20·0 per cent.
	Second "	10·7 "
	Third "	12·0 "
	Fourth "	11·4 "

The saving here represented 13·2 per cent. on the fuel actually used.

Plant No. 3, consisting of two water-tube boilers	First test	19·8 per cent.
	Second "	12·2 "

The saving here represented 9·7 per cent. on the fuel actually used.

Plant No. 4, consisting of one marine-type boiler	First test	19·6 per cent.
	Second "	7·9 "

The saving here represented 17·4 per cent. on the fuel actually used.

In these test-results, the first represents the original trial under the ordinary conditions of working; the second represents the results obtained when the plant had been altered on scientific lines and was worked by the expert staff of the Society; while 3 and 4 represent the results obtained at some later date, when the plant was again under the control of the ordinary stokers and boiler engineer attached to the works. The efficiency in this case had fallen back slightly, as might be expected, but was still much better than in the original test.

Limit of space will not allow more detailed figures of tests to be given from the two reports of the Hamburg Society, and those interested are referred to the original pamphlets. The following summary from the Report for the year 1904 will show, however, the activity of the new organization:—

During the fourteen months ending December 31st, 1904, 32 installations were submitted to the first thorough examination and test, and 71 firemen received instruction in their duties at these plants for a period of 175 days. 74 installations were visited for the second, third and fourth time, and in connection with these visits 190 tests were made, as a check upon their continued good working. The number of reports issued from the central office in connection with these and other tests was 226.

As a proof of the position which the Society has attained in Hamburg and Germany, it may be stated that a sum of £300 was granted to it in 1903, in order to carry out some special steam-raising trials, and a central model boiler installation was erected in Hamburg for this work. One hundred and thirty complete steam-raising trials have been made at this model boiler plant during 1904, and the results obtained are to be circulated amongst the members of the Society in a special report. A summary of the results of these trials is contained in the report for the year ending December 31st, 1904.

The practical lesson which we in this country may learn from the above account of the work of the Hamburg Society, is, I think, that the smoke-problem is to be solved, like many another problem, by application of that old English method of *self help*, which is now sadly out of fashion. Manufacturers, and fuel-users generally, in this country, must be taught that the emission of black smoke is largely preventable, and that the smokeless combustion of fuel *promotes economy*, when carried out under proper supervision. It is for this reason that the writer has given instances from the annual reports of the Hamburg Society to prove the saving in fuel-consumption which results from the working of steam-boiler plants on scientific lines, with properly trained stokers.

What is wanted in this country is some society or organization which will provide fuel-users with the technical advice and oversight required for obtaining the smokeless combustion of fuel in their own works. The Hamburg Society, in the author's opinion, is such an organization, since it is showing manufacturers how to combine together to attack the evil at its source, namely, the boiler and heating installations in their own works. It would be well if similar societies were started in every large centre of manufacturing industry in this country. The writer, as foreign corresponding member of the Hamburg Society, will be pleased to give all the information in his power, relating to the organization and work of the Society which he represents here to-day, and of which he has given a brief account in this paper.

ON PRECAUTIONS NECESSARY FOR MAKING RELIABLE OBSERVATIONS ON SMOKE DENSITIES.

By JOSEPH W. LOVIBOND.

IN dealing with the nuisances arising from the consumption of fuel, the subject naturally falls into two divisions, the avoidable and the unavoidable; in reference to the former I was asked by the Coal Smoke Abatement Society to design an instrument capable of measuring and recording the density of smoke as it issued from chimneys.

In designing such an instrument certain conditions must be complied with to make the readings reliable, namely:—All observations must be made under similar conditions. The light used for comparisons must be uniform in character. In the scale of standards used for matching, the divisions must be equal, and the unit recoverable.

It will be shown how these requirements are met, whilst describing the instrument, after considering the principles on which it is founded.

The foundation rests on the Tintometer equivalent colour-scales, which have the power of matching and recording in quantitative terms the colour-sensation excited by any substance.

Under this system the most complex colour can be qualitatively described by means of two colour-terms and one light-term, and when these are associated with their unit-values of intensity, the description becomes quantitative.

The order in which two colour-terms are associated is natural and invariable, they are always adjacent in their spectrum-order, red and violet being considered adjacent for this purpose.

The light-term is one of degree, representing a definite degree of luminosity between the extremes of the white light used for comparison and its total absorption.

The equivalent colour-scales are correlated to some chemical colour-constants, and therefore have a physical basis by means of which their truth can be tested. They have been adopted by some international

societies, and are used in many industries; a detailed description of their construction is given in my new work on "Colour Phenomena."

The photographic energy of the colour-rays, separated by the standards, was shown in a negative, taken from a screen made up of the glass standard-colours; the light used was equal to the absorptive value of the glasses, therefore the separated rays were free from the admixture of white light.

In the past some uncertainty has existed concerning the relation of colour-increase to density-increase, some considering that they were in direct ratio, but up to the present no such instance has been found, and it may be accepted that each substance or condition of substance has a rate specific to itself, which when once established can be tabulated and charted in curves furnishing a means of identifying that substance or condition of substance in future. The difference between the curves of the direct rate theory and those of the specific rate obtained by actual measurement were shown side by side on a chart, dealing with the differences between two makes of neutral tint glass; the density-increase was obtained by the successive superimposition of equal thicknesses.

A single colour-measurement is only the statement of an isolated fact, which although useful for many purposes cannot alone be relied on as a means of identification; it may even happen that two dissimilar substances coincide in colour at one point, they will however always diverge as their densities recede from that point.

The instrument is a pocket edition of one used for measuring the colour of landscapes, gases, and incandescent bodies. It consists of a rectangular tube $1\frac{1}{2}$ inches by 1 inch section, 4 inches long, one end is closed except a circular $\frac{1}{8}$ inch opening used as an eyepiece. The purpose of the tube is to cut off disturbing side-lights, which never equally affect two colours placed side by side, as when matched without this protection a change of position will certainly disturb it.

In the middle of the tube is a diaphragm having two $\frac{1}{8}$ inch square apertures half an inch apart; one is intended to command the smoke to be measured, and the other is filled with a beam of diffused daylight for comparison; the object of the $\frac{1}{8}$ inch openings is to limit the field of view to the area of smoke under observation.

At the open end the base is prolonged two inches, forming a stage to carry a reflector, which consists of a slip of Chance's matted white opal glass fixed at an angle of fifteen degrees with the prolonged stage. This collects the light from a large area of overhead sky, reflecting it to the eye through one of the apertures as a beam of diffused daylight; this

overhead light is necessary, because light taken from the altitude of chimneys is too variable for reliable work. Fifteen degrees is found to be a suitable angle for the reflector, and is adopted for all this class of instrument in order that their readings may correspond.

The standards are slips of neutral tint glass sliding in grooves on one side of the instrument, intercepting the beam of diffused daylight and reducing its luminosity according to the absorptive value of the glasses themselves, which had previously been correlated to the equivalent scales; each glass and each combination is separately measured, and their values inscribed on the top of the instrument in neutral tint units for ready reference. When a smoke is matched its density is recorded in units of white light absorbed; the values for No. 11 instrument are as follows:—

Glass Combinations.		Light Units absorbed.
No. 1	= ...	3·9
„ 1, 2 ...	= ...	6·8
„ 1, 2, 3 ...	= ...	9·6
„ 1, 2, 3, 4 ...	= ...	12·5
„ 2	= ...	1·35
„ 2, 3... ...	= ...	4·0
„ 2, 3, 4 ...	= ...	6·6

The photographic evenness of the neutral tint scale of equivalent colour-combinations was seen in a negative from a screen made up from the glass standard scales.

Different makes of neutral tint glass vary both in colour and rate of light-absorption, making it necessary to establish the rate of each sample for the purpose of selection; a rate is established by measuring a single slip, and then successive additions until all light is absorbed. The results are tabulated, and the curves established, as in the chart, where the ordinates correspond to the units of the colour-scales and the abscissæ to the number of superimposed glasses.

It will be noted that two makes of neutral tint glass are used in this case, one marked series 9, and the other series 30; this is because the free colours in the working part of the scale of series 9 are blue and green, while those of series 30 are yellow and orange. These colours naturally neutralise each other, making their combinations more neutral in tint than combinations of either series alone, the mixture is, therefore, better adapted for matching smoke.

One precaution is imperative, no direct sunlight must be allowed to impinge on the reflector, the reason being that measurements made by

diffused daylight agree with the test conditions for uniformity, whilst those made in sunlight do not, they also vary with every variation in sunlight intensity.

The reason of this variation is influenced by at least two contributing causes: first, direct sunlight is yellow-orange in colour and is therefore differently affected by two dissimilar bodies; second, direct rays are in a different condition and give rise to a different set of colour-phenomena from those caused by the same light after diffusion.

Smoke-density when recorded in units of white light obstructed is a reliable index of bad stoking, recording as it does the visible part of the nuisance, but takes no notice of the distilled gases which always accompany imperfect combustion.

In order to apply the colorometric test to the gases given off by the imperfect combustion of different fuels, an apparatus was constructed consisting of a furnace with a chimney surmounted by a chamber having a series of sinuous surfaces over which a continuous stream of water flowed, meeting the smoke in its upward course. The following fuels were experimented on and the specific curves of their smoke-solutions plotted on a chart, the wide variations indicate variations in constituents.

No.		No.	
1	Coal Gas Smoke.	8	Steam Coal Smoke.
2	Anthracite Coal Smoke.	9	Beech Wood ,,
3	Carmel ,, ,,	10	Ash ,, ,,
4	Birley ,, ,,	11	Pitch Pine ,,
5	Newbury ,, ,,	12	Elm ,, ,,
6	Braysdown ,, ,,	13	Oak (seasoned) ,,
7	Norton Hill ,, ,,		

THE EFFECT OF SMOKE ON PLANT LIFE.

By Miss M. AGAR.

FROM experience in working as landscape-gardener to the Metropolitan Public Gardens' Association I have been asked to say something about the effect of smoke on vegetation.

Soot is the chief enemy to vegetation. The finely divided particles of carbon which constitute soot settle in masses as smuts, or drift about, invisibly small, and become evident as a deposit. They penetrate into the pores of plants and interfere with all functions of the leaves; with transpiration of water-vapour, and with inspiration of air. Unless transpiration is freely allowed the sap can circulate but sluggishly. Unable to get rid of water no more can enter, and the passage of food-materials from the root is checked; and unless air, with its supplies of oxygen and of carbon dioxide, can enter, the plant suffers starvation in that direction also. Indeed, were it not that a plant's stomata are almost entirely on the under sides of the leaves, no plant could survive a London fog.

Everyone has noticed how quickly the colour of paint deepens in town. The emerald-green of newly painted Westminster Bridge in a few weeks is a sober, olive hue. Consider what a deposit that so darkens colour must be to a plant which depends on light for all its chemical processes. Every dirty plant is living practically in twilight. About once a week, during the winter months, the plants in the little garden of the Bank of England, are *hand* washed, as one washes room-plants, with soap and water, otherwise they would hardly appear green. After a spell of foggy weather I have seen the leaves iridescent with a tarry film, so greasy is the soot. Of course, hand-washing is out of the question in large spaces, and one has to fight this evil of dirt by planting only such things as have shiny or smooth leaves, on which soot cannot get too firm a hold for rain to partially dislodge it. Even so they are but sickly specimens, and in all cases the lower leaves tend to drop off prematurely, owing to their receiving a double portion of dirt in drips from above. London shrubs rarely "break" from below; the stems are too coated for young life to get through.

Another method of helping the plants is to give liberal root-feeding. They must be stimulated to make the most of every clean breathing space and produce fresh leaf-surface whenever possible.

I have mentioned smooth leaves as an essential qualification for town-plants; a deciduous nature is also an advantage for obvious reasons. The plane goes one step further and sheds its bark too. I know one sees evergreens as often, if not oftener, than deciduous shrubs in London, but that is because planting is done for purposes of privacy as much as for beauty. The ivy edging in the Grocers' Hall garden *is* somtimes deciduous, as though it realised the virtue of such a habit. After last winter, which was a particularly black one, it shed all its leaves and started fresh. The leaves that came away were more like black suède leather than vegetation.

No conifers, except the gingko, which is hardly recognisable as a conifer, can thrive in smoky atmospheres, everything is against them. They are evergreen and their bark is rough and frequently resinous; conditions which cause their final suffocation from dirt. It is sad to see the fine cedars in the Holland House gardens dropping their lower boughs and yearly looking more wretched. Years ago there were fine cedars in Fulham; they have nearly all disappeared, and the names of houses and roads are their memorials.

Another character must be taken into consideration when experimenting with shrubs in London, the season at which growth starts. Late shooting things are more likely to thrive than those which bud early and have their young leaves exposed to the fogs and dirty air of the season of domestic fires. The plane again shows its suitability for town-life by its slow start into leaf; the catalpa and ailanthus are good trees for the same reason.

Not only has soot a directly baneful effect on plant-life, but it also attacks plants through injuring the fertility of the soil. The fine particles settle in the interstices, and make it impervious to air, and, without air, soil soon sours. The fertility of the ground depends on bacterial activity, and whether or not soot is a poison to these organisms I know not, but certainly a lack of air is fatal. Ordinary London soil is sadly unfertile; we have always to bring in fresh soil to revivify it, and I imagine that the chief virtue of the new soil is, that it inoculates the old soil with fresh germ-life. Possibly manure serves the same purpose in addition to its obvious one of supplying plant-food, and improving the mechanical conditions.

The pity of all this is that things *would* grow in large towns if only the air could be purified. Houses conduce to warmth and shelter, and by

their contrast to vegetation add greatly to its charm. Many country towns have famous private gardens, Salisbury, for example; whereas the little gardens of the better class London house are generally eyesores of limp grass, smutty paths, and enfeebled privets and aucubas. It is to be hoped that electricity and an enlightened public conscience may remedy this by abating the smoke-nuisance.

[*This Discussion applies to the subject before the Conference on Thursday morning—"Factory and Trade Smoke Abatement."*]

MR. W. D. SCOTT-MONCRIEFF (London) said that he had been in two minds about joining in the discussions of the Conference because his own ideas were considerably in advance of those which were generally accepted. It appeared however, from the address which had just been given by Sir Wm. Preece, that in Germany they were moving somewhat on the lines which he (the speaker) had advocated just twenty-five years ago in a paper read before the Society of Arts entitled, "Smokeless London." It was about the time when the Smoke Abatement Society was founded, and the proposal that was then in favour was one made by the late Sir Wm. Siemens advocating the use of coke in domestic fireplaces, supplemented by gas. We now have the interesting experience of Sir Charles Cookson, in the paper brought before the Conference on the previous day, from which it appears that he has carried out the suggestion made by Sir Wm. Siemens twenty-five years ago, giving details of how he has used coke and gas in his own house in London. The solutions of the smoke problem now proposed as being most feasible embody the position all along maintained by the speaker, that there must be a separation of the gas from bituminous coal before using it in domestic grates. He had always pointed out that a material which required exposure to the temperature of a red hot retort for six hours in order to deprive it of its gas was not likely to be treated so as to produce no smoke in a domestic grate, even under the skilled supervision of the most highly educated housemaid. He then went on to give a résumé of the following letter which appeared in "Nature" of December 16th, 1880:—

"I write for the purpose of expounding a scheme which, if adopted, would make London a smokeless city.

When taking upon myself to explain a subject in a few minutes which has taken many years to develop in my own mind, there is a great temptation to put the reader in possession of the steps which led to the conclusion. The conclusion itself, however, has so much to recommend it that I will confine myself to the results of my reasoning only. It is enough to say that

they were arrived at, to a great extent, by an exhaustive exclusion of less feasible plans.

First then I propose to take advantage of the existing plant of the gas companies. I find they are amply sufficient for the purpose.

Instead of taking 10,000 cubic feet of gas per ton from the coal, I propose to take 3,333 cubic feet, and to pass three times the quantity through the retorts, or any other proportion that may be found most convenient. The result of doing so is startling.

The companies will have doubled the quantity of by-products they have at present in the shape of tar and ammoniacal liquids; the community will have 24-candle gas instead of 16-candle gas; the fuel resulting from the process will light readily, and it will make a cheerful fire that gives out 20 per cent. more heat than common coal; London would become a smokeless city.

In dealing with the figures I shall take them roughly, but in such a way that by including a few outlying corporations they could be made absolutely correct.

I take the total annual consumption of coal in London to be 6,000,000 tons. Of this I take 2,000,000 tons to be the annual consumption of the gas companies. The total quantity of fuel used for general purposes I take to be 4,000,000 tons of coal and 1,000,000 tons of coke sold by the gas companies.

We shall now see what would be the result if we treat the whole of the 6,000,000 tons in the retorts on an extraction of less than three hours, instead of the six hours at present prevailing.

The total quantity of 16-candle gas consumed in London may be taken at 20,000,000,000 cubic feet. This would be at the rate of 3,333 cubic feet per ton upon 6,000,000 tons, the total quantity of coal consumed in London. The residual smokeless fuel would amount to 5,100,000 tons. Of this 1,000,000 tons would be required for the extraction of the gas, leaving 4,100,000 available for the general uses of the community. This has to be compared with the 4,000,000 tons of coal and the 1,000,000 tons of coke already referred to as consumed at present. Now the smokeless fuel which results from an extraction of 3,333 cubic feet of gas per ton has a heating capacity fully 20 per cent greater than coke. This gives us the exact equivalents of the 5,000,000 tons of fuel at present in use.

So far the account as regards the fuel available for the community balances. We may now deal with the difference in value between 16 and 24-candle gas. As the value of the gas varies directly as its illuminating power, the calculation is very simple. If we take the average price of 16-candle gas to be 3s. 6d. per thousand cubic feet we shall find the total value of the 20,000,000,000 consumed in London to be £3,500,000, but as we have by my scheme the same quantity of 24-candle gas, the value will be increased to £5,250,000; here then we have an annual sum of £1,750,000 to place to the credit of the system.

Turning now to the by-products; seeing the gas companies by the new arrangements would subject three times the quantity of coal to the heat of their retorts during the period when the tar and ammoniacal liquors pass off most rapidly, I do not think I am wrong in estimating the yield at double its present amount. Taking this upon the tar and ammonia to yield 3s. 9d. per ton of coal, we find the total value of these by-products to be, at present, on the supposed consumption by the gas companies of 2,000,000 tons of

coal per annum, £375,000. This being doubled under my scheme, an additional sum of £375,000 must be placed to its credit.

But the basis upon which we have hitherto been arguing is that the gas companies under the proposed scheme are getting their coal for nothing. We have been supposing that the community become the purchasers of 6,000,000 tons of coal and hand it to the gas companies. At present London only pays for its general consumption on 4,000,000 tons of coal and 1,000,000 tons of coke. Let us now suppose that the companies pay the same sum annually that they do at present for their coals; if so, they would pay upon 2,000,000 tons, or an annual amount of £1,600,000 if their coals cost 16s. per ton. From this falls to be deducted the money they at present draw from their sales of coke, which, when taken at 6s. per ton of coal carbonised under the existing system, still leaves a sum of £1,000,000, which they could afford to pay per annum for the use of the 6,000,000 tons of fuel as proposed in my scheme. We will now take the total payments of the community for their coal to be upon 6,000,000 tons, for which we will further suppose they pay at the rate of 16s. per ton first cost. This would amount to £4,800,000 per annum. From this falls to be deducted the £1,000,000 contributed by the gas companies for the use of the fuel, also the £1,750,000 charged on the difference between the 16 and 24-candle gas already referred to, also the sum of £375,000 of additional income from the by-products. This would leave a net sum paid by the community for its fuel under my scheme of £1,675,000. Under the present system they have to pay, say 16s. per ton on 4,000,000 tons of coal, and say 12s. per ton on 1,000,000 tons of coke. This makes in all the sum of £3,800,000 per annum. Here then we have a balance in favour of my scheme of £2,125,000 annually. This may be taken as the yearly value of London smoke, which I propose to convert into useful products by *the plant at present in use.*

I have only in conclusion to say one or two words about the efficiency of the scheme as regards the fuel. It lights easily, it gives off no smoke, it makes a cheerful fire, it gives out more heat than either coal or coke, it will be cheaper per heat-unit than the coal at present in use, London would become a smokeless city, and all that would fall to be deducted from the sum of £2,125,000 per annum would be confined to a few items, such as the cost of additional capital required for transit appliances, and the terms to be made with the gas companies for carrying out the scheme."

All the figures given for the year 1880 apply pro rata to the present time. The speaker would have still been in doubt as to any practical result accruing from the re-introduction of his proposals, but that a reference in Sir Charles Cookson's paper to what is now being done in Germany seems to bring them into line with the most advanced practice of the present time. After remarking that nearly all the coke in the market is a by-product of gas retorts and its quantity insufficient to meet the demand in London, an observation that applied equally to the proposal of Sir William Siemens, he goes on to say that the only remedy is to produce "charred coal" which is the very material the speaker advocated in his paper, and further "this may be done and has been done in Germany and elsewhere." It is just possible that the changed conditions as to competition, in which the gas companies now find themselves, may lead them to

inquire as to how far their existing plant, with some alterations, is capable of adding to their dividends, and at the same time making London smokeless.

Judge Gibson (Edinburgh) said that experience in the prevention of smoke in Edinburgh had proved that where boilers had not too much to do in the way of raising steam, and with ordinary suitable fuel, it was generally possible to reduce smoke nuisance to a minimum by careful firing. Consequently, arrangements were frequently made with owners of furnaces to allow the inspectors in charge to supervise the stoking for a few hours, allowing the offender to watch the result, and if, as was usually the case, the emissions of smoke were reduced to a minimum, he was effectually silenced. This evidence was useful in the case of a prosecution which would follow a further offence. Of course, the adoption of mechanical appliances, such as automatic stokers, steam jets, and the distribution of air over and behind the furnaces, also contributed in a large measure to the abatement of smoke nuisance, and it was the common experience that where owners were convinced of the utility of these appliances, they were not backward in adopting them. For the improvement of the defective draught and to assist combustion, these, without doubt, were all more or less useful, but the burgh engineer was convinced that the methods adopted by their inspectors were the correct ones for checking the careless working of steam-boiler or other furnaces. The stoker or fireman was, after all, the man with whom rested, to the largest extent, the modification or otherwise of smoke nuisance, and by whom the merits of the very best patent appliance could be nullified. He it was with whom the inspectors endeavoured to come into direct contact. The effect of their periodic visits to the different works throughout the city, was that these men were kept constantly on the *qui vive*, and, as a class, they were usually found to be anxious to do their best. Indeed, in a great number of places, it was as much as their place was worth to persist in giving cause for complaint. About seven years ago the Burgh of Portobello was amalgamated with Edinburgh, and in this district there was a large number of works and manufactories all clustered together. As little or no supervision was exercised previous to the amalgamation, these were great offenders for a time, but the improvement was now most marked. Whatever might be the benefit of all these different kinds of smoke-preventing appliances on the market, and in actual use, it was the experience of Edinburgh that with careful and intelligent firing, and with the flues periodically cleaned out, there need be no excessive emissions of black smoke. It was, however, difficult to find experienced men who had a knowledge of their work. The duties were arduous and not very highly paid, and very often a man was engaged whose sole idea was to fill the furnace up with coal. These men were the real cause of smoke nuisance, and it was to them that strict attention was given. One of the queries in the list sent by the secretary of the Conference was to the effect, whether the existing powers possessed by the local authority for the prevention of smoke nuisance might be amplified in any

particular. It might be suggested that when one local authority was not satisfied with what an adjoining authority was doing in the matter, and especially if it could be proved that the first party was suffering thereby, then independent steps might be taken against the offender. To the south of Edinburgh there were several large breweries and other works, and the city got the benefit of their black smoke when the wind was in the right direction. It would be very beneficial could the city authority interfere, as there were several glaring offenders among them, and the burgh engineer understood that such powers did exist elsewhere.

MR. W. H. PATCHELL (Charing Cross, West End & City Electric Supply Co.) said that he was compelled to differ with the statement made by Commander Caborne on page 39 of his paper, that "suction draught, hot air and short chimneys might be a solution of this trouble," as after considerable experience with this system he was obliged to abandon the hot air plant as a most disheartening failure, and when the works in which the plant was erected were enlarged, the medical officer of health for the district requested that the second chimney, which was necessitated by the increased works, should be carried up higher than the first chimney which was used in connection with the fan plant, and for this reason the second chimney was built 120 feet instead of 100 feet in height. Suction draught had been used throughout the company's Lambeth works ever since, and it was possibly one of the largest installations of the system in England. The system, however, required very careful handling, as the nuisance from grit lifted by a strong draught, might readily be greater than the smoke which it was desired to avoid. He had tried a large number of mechanical stokers of various types, but had not yet found a thoroughly satisfactory one. Where the plant had to handle a suddenly varying load, the variations being caused by atmospheric changes, and out of the control of the works manager, no mechanical stoker that he had yet tested was able to compete with a thoroughly competent human stoker. It was stated that mechanical stokers would diminish the number of men employed in a boiler-room ; they resulted, however, frequently in the necessity of a staff of mechanics to carry out repairs, which consumed the saving in stokers' wages. Further, many classes of coal had a very awkward habit of hanging on a stoker, which necessitated the introduction of a poker, this caused the emission of large volumes of smoke, in fact some of the stokers that he had tried, when under the control of the maker's own picked men, might almost be said to have made more smoke than steam. They had been told that morning that Berlin was beautiful in its absence of smoke. He had frequently seen dense volumes of smoke from factory chimneys in Berlin, quite as black as any smoke that he had ever seen in London. Generally speaking, however, there was much less smoke in Berlin than in London, because private houses used enclosed stoves and not open grates. Many people had not yet realised

that the bulk of what is called the smoke nuisance was caused not by factories but by ordinary chimneys which were not at present under control.

Mr. Julius Geldard (Bradford) said that Commander Caborne had shown them how inefficient the majority of the firemen employed were, and how necessary it was that they should be more fully instructed in the intricacies of boiler firing, with which he was most thoroughly in accord. Machine stoking, however, presented a solution of the difficulty in that it automatically reduced the number of points in which an imperfectly trained fireman went wrong, and it was certain that the best machine stokers, when used with common sense, were smoke preventers *with any kind of fuel.* It was essential that factories in London should be independent of any specific coal-field, in case of strikes, and every furnace must be constructed so that it could be adapted to suit different coals, as well as varying loads. There were machine stokers in general use which would do this far more efficiently than the best trained fireman could do ; one association in the north having fitted as many as 200 boilers during the last two years. Hundreds of London firms were using machine fired boilers and smoky north country coal, whose names never appeared before the smoke authorities, because their chimneys were clean. He thought the author of the paper did not realise the enormous output of the machine stoking trade ; one firm alone turned machines out at the rate of 15 to 20 a week, and others on a similar scale. It must not be forgotten that manual stoking was a dirty, hot and uncomfortable occupation, and the better class of man would not usually undertake such work ; but with the modern high class machine stoker, conveyor and elevator fed, the obnoxious physical elements were removed and intelligent men could be obtained. With reference to the 15 or 18 per cent. CO_2 that the author recommended should be found in the waste gases, the figures were not possible by hand-stoking using bituminous coal, without making smoke, and carbonic oxide would be found in considerable quantities, thus causing a loss. With reference to the wear and tear of mechanical stokers he would say that one of the largest northern lighting stations with over 12 years' experience of machine-stoking, stated that the repairs averaged less than £1 per boiler per annum, and they burned over 40 lbs. per sq. ft. of grate surface per hour on load without smoke. Machine stokers could burn both dry Welsh and anthracite when fitted with hot air feed, but as anthracite cost in London from 18s. to 21s. 6d. per ton and a good steam small was being used by many firms at 10s. 6d. to 12s., it did not appear that at present anthracite could compete.

Mr. R. S. Richards (London) said that no one could have read the able article by Commander Caborne without perceiving the absolute necessity for trained and educated stokers. The very large installations would no doubt extensively adopt mechanical contrivances, but there were thousands of smaller

steam users who would continue hand-firing, and in London it was not generally known, but it was a fact, that smokeless coals could be obtained as cheaply as the bituminous coals. Welsh dry coals and anthracite coals could be delivered in the river from 10s. 6d. to 15s. per ton, and considering that they had a higher evaporation than north country coals he believed they were really cheaper. In view of cheap electricity he looked forward to the time when our cooking and house-warming would be done by this agent. No one, if they could help it, would have gas in their houses; but until they got electricity, he should advise gas for cooking and stoves burning anthracite. For heating, economy and cleanliness, nothing could equal anthracite. The intelligent and economical French and Germans had discovered this, and when it was realized that this fuel exists in millions of tons almost at our doors, he was astonished that we in London refuse to use it, preferring the dirty, wasteful, costly open fire-place.

DR. ORMANDY (Warrington) stated that in an early paragraph in Commr. Caborne's paper the statement occurred "what I particularly desire to lay stress upon is the paramount value of the personal equation." The point which he (the speaker) desired to lay stress upon was the paramount importance of reducing the personal equation to the smallest possible element. The object of all manufacturers at the present time was to reduce dependence upon skilled manual labour by the introduction, so far as was possible, of mechanical means to attain the same ends. It was for this reason that every encouragement should be given to those who were working upon the designing of improved mechanical stokers. At the best the human agent could only approximate to the ideal condition of stoking, namely, the introduction of the smallest possible amount of fuel with the greatest possible frequency. This could be attained in a far superior way by mechanical means. Mr. Kershaw referred to the Hamburg Smoke Abatement Society. The speaker could speak from personal observation as to the valuable work which was being done by this Society, but the conditions in the two countries were not exactly parallel, for the German worker was more accustomed to discipline, and more open to instruction. Years ago their technical managing director, Dr. Markel, had insisted that the combustion of coal was a chemical operation, and as such should be in the charge of trained chemists. Of course it was only by the harmonious working of the engineering and chemical staff that best results could be attained, but after the plant was erected, there was no question that the chemist was the man who should have control. In answer to the Chairman's question, he was able to confirm the statement that Messrs. Crosfields were saved over a thousand tons of coal per week, and this meant a great deal more than appeared in that figure, since it implied that they were saved the necessity for using almost double the number of boilers, with all their expenses of depreciation, firing, up-keep, etc., and the saving was at least equal to £25,000 per annum. As this fact seemed to have

evoked considerable interest, he was pleased to be in a position to say that the directors of the company had decided to throw their works open to visits from those who were particularly interested in questions relating to fuel and water economy. It had been urged that small works could not afford to employ a chemist whose knowledge and training were of the required calibre. This was perhaps true, but surely it would be possible to arrange some central authority who would be able to interpret results obtained by youths sent out to these various small works, youths who would be quite competent to carry out the necessary examinations of the samples. The results so obtained would be interpreted by the central authority and the works run in accordance with such interpretation. To show how little, comparatively, the expense need be, the speaker stated that it would be quite possible for two youths to carry out all the daily tests required in connection with their own large installation of 23 boilers and numerous furnaces. He ventured to think that some society on the lines of the Manchester Steam Users' Association, run for the mutual benefit of the subscribers, might easily be arranged to carry out the programme mentioned very shortly above. His own firm had been so frequently approached about this matter that they were (for a number of works in the vicinity) taking upon their shoulders the work ascribed above as being the function of a society founded on the line of the M. S. U. A.

Mr. W. H. Atkin Berry (London) as a member of the Coal Smoke Abatement Society, replied to some of the observations which had been made by various speakers in reference to that society. It had been suggested by some that it should desist from prosecuting, and should in substitution instruct and advise offenders as to the best methods of preventing smoke. Such suggestions appeared to him to indicate an entire misapprehension alike as to the first duties of the society and its means. Its first duty was to enforce the existing law, which requires that black smoke *shall not be emitted*. It was established that such emission is preventable, and it was the duty of the society to see that the rights of the public are respected in this matter; it was not necessarily a condition that it should assist manufacturers in doing that which the law required of them. The law insists that burglars shall not break in and steal, but no reasonable person would suggest that the police force should desist from pursuing the offending burglars and resolve itself into a philanthropic society for teaching burglars how not to steal. The Coal Smoke Abatement Society would gladly *add* to its other duties the more pacific course suggested, but the necessary funds for that purpose must be forthcoming. The society depends upon voluntary contributions, and the public, while looking to it for protection, appeared to overlook this fact. Its efforts and the scope of its operations were seriously restricted by need of funds, and while welcoming suggestions it asked also for the financial support essential to give effect to them, and for securing that which was the right of all, viz., immunity from the nuisance of smoke, and

from the pollution of the atmosphere. The suggestion which had been made, that the society should recommend particular methods and systems of abating smoke was one which could hardly be entertained; it would place it in a false position; the Conference, however, might feel assured that the society is ready to assist in every possible way in securing the object of its existence, viz., the abatement of smoke. As to the suggestion, made by Sir William Preece in his address, that the society should "record the firms who had adopted scientific measures and shown their economical results," Mr. Berry pointed out that it had already adopted that course, and the paper read that day by Dr. Rideal had specifically detailed the results. They were still pursuing those investigations, and would gratefully receive, examine, and record all information upon the subject which might be furnished.

MR. J. MACAULAY (Liverpool) said that it would be well if the word "black," in relation to smoke, were omitted from any future Public Health Act. Smoke, whatever the colour, consisted of vapours produced by the partial combustion or distillation of coal, or in other words, of valuable hydro-carbons and sulphur compounds, the visible portion; and the equally valuable invisible portion, the poisonous gas, carbonic oxide, the ranges of colour being due to the quantity of sulphur compounds present. Now, although carbonic-oxide might be emitted from a smokeless chimney, the presence of smoke was a sure indication of the presence of the gas; and the effort intelligently made to stop the emission of smoke would mean the preventing of the emission of carbonic-oxide. When a manufacturer was convinced of the fact that burning his coal to produce only CO meant the production of 4,450 British thermal units, whilst burning it to CO_2 meant the production of 14,540 units, he would co-operate with them in preventing smoke. He could find out by using an automatic CO_2 recorder whether his coal was being burnt properly or not, and if a fireman knew that his name would be placed on the record taken during his term of duty, he would be induced to do his best. Mechanical stokers, of the coking type, were efficient if kept in order and used for steady loads. But where the load was varying good hand-firing was best. In Liverpool the smoke inspectors, who were trained engineers with Board of Trade certificates, visited the works and advised manufacturers to direct their men (where hand-firing was carried on) to fire regularly, to throw on small quantities at a time, and frequently.

MR. E. P. GROVE (Central London Railway) said that, as the engineer of one of the large power stations, he thought the London Smoke Abatement Society went rather too far at times, and that their action was approaching persecution. His company was doing all in its power to obtain smokeless economical combustion of the fuel. They had replaced their mechanical stokers by hand-firing, burning Welsh small coal, and finding that caused trouble with

the coal dust and was still liable to smoke, they washed their coal, and now when experiments were being made to obtain smokeless combustion with other classes of coal and mechanical stokers, if they had the misfortune to make smoke, they were reported and threatened with proceedings. An automatic CO_2 recorder was used, and regular boiler testing and training of firemen was adopted, the stokers being paid a bonus on the results obtained. Large sums were now paid monthly to the stokers in this way, over and above regular wages. An all round efficiency of 74 per cent. was obtained in the boiler house. They had been carrying out a large number of experiments in stoking methods, and had tried many alterations to a mechanical stoker with a view to finding a satisfactory solution of the smoke problem, and were prepared to go still further, but this work could not continue if the Coal Smoke Abatement Society adopted a persecuting spirit, and these experiments would have to cease if the officers of that society decided to report and fine them for every slight emission of black smoke. He should like also to say that allowance should be made to those who have to carry out their work by the burning of large quantities of coal, and that the amount of smoke emitted should be considered in proportion to that quantity, and particularly that those who the society knew were endeavouring to find better means of abating the smoke, should be treated differently to those who make little or no effort. He thought that only on lines such as this would the question be definitely decided, and the best means, having in view commercial success, be brought to light, as after all he did not suppose that the Smoke Abatement Society really wished to stifle commercial enterprise. He could not agree with those that argue that smoke abatement must *necessarily* follow economy.

Friday, December 15th, 1905.

SUBJECT: "ADMINISTRATION, LEGISLATION AND NECESSARY REFORMS."

ADDRESS

By SIR WILLIAM B. RICHMOND, K.C.B., R.A.

IN the presence of so many scientific authorities, whose practical abilities are such as I have no claim to, it would seem most desirable to further the objects which we have in view if I offered such expert evidence as has come before me in a long experience. But while I do this, I cannot refrain from expressing my convictions upon ethical as well as æsthetic principles. Both are merged together, or anyhow come into touch somewhere.

We all know that light gives life and colour, we all know that flowers lose their brilliant tints if placed in a dark cellar. Man is a kind of flower, he too loses his colour in a dark prison. Pictures become black or deep yellow if shut up in a case for any lengthened period; this has been always known to artists. There is a letter still extant from Rubens to a friend whom he requests will have a picture which he has despatched to be immediately taken out of the case and placed in the "sun" that it shall recover its clearness and brilliancy of colour. The Venetian painters, as we all know, were the great colourists of Italy, hence of the world; it is related of Titian by a contemporary writer that it was the habit of the master to place his pictures to dry in the sun, exposing them to it from the roof of his house in Venice, that he also allowed his pictures to remain out all night that they might receive the benefit of the dew of the morning mists. Both these experiments I have tried with disastrous results. It is important

that oil, whether linseed or poppy, shall dry quickly, otherwise it becomes sour and the carbon in it if not quickly dispelled forms a coat of opaque lustreless black as a skin over the surface of a picture. The effect of dew is that it purifies the oil, being in the nature of a solvent of impurities. Some one more learned in science than I am will be able to tell the conference why this is so, I only advance my experiments for consideration. There are many other technical topics on which I could dwell, but this is neither the time nor place except to mention them superficially. There was held some forty years ago a Royal Commission, the late Prince Consort was chairman, to consider the desirability of transferring the whole collection of pictures in Trafalgar Square to South Kensington. Many experts in various matters were examined before the commission, among them Faraday gave evidence; my father, who sat on the commission, told me that Faraday said, "Every smut, however small, which remains upon the surface of a picture, even if the colour is dry, leaves behind it a greasy matter, so potent, that it can only be removed by a *solvent* of such a strength which being applied will eat into the surface of the paint."

Owing to the poison in the atmosphere of smoky cities, the most noble and the most durable of all methods of painting, "Buon Fresco," is out of the question. During the period of the crystallisation of the lime in concert with the pigment not superposed but incorporated into it, if there is gas about, or any other poison, the lime is injured, and the marriage between the lime and the powder of the pigment is only partial, hence in time the colour, together with the only partially crystallised lime, falls off or can be dusted off. Briefly I will tell the conference what Buon Fresco is. The wall upon which it is to be applied must be thoroughly dry. Upon this dry wall a thin layer of lime and marble dust liquid and ground is applied, but only upon the portion of the painter's design which he intends to complete in a morning. The colours are ground in water, but the water must be pure; any water which is in the slightest degree poisoned with gas or any other enemy to lime must be avoided. The water must be boiled before using. Water is the only liquid used in Buon Fresco, save perhaps a little wine or fine vinegar. The lime does the fixing! You will see at a glance that in this, which appears at first sight to be a frail material for fixing, but which is in truth a very strong binder, the slightest enemy to its adhesive or binding power will be fatal.

Coal smoke is fatal to the proper hardening of lime, even upon lime-plastered walls which have no decoration applied to them.

The failure to be permanent of the Frescos in the Houses of Parlia-

ment is mainly due to two causes: to the contact of the lime with gas and other poisons; and to an inadequate incorporation of the pigments within the strata of lime, and among the angles and surfaces of crystallisation.

But in the country, given that the walls of a building are quite dry, and that there is pure water to be had and no gas works near, there is no reason why Buon Fresco should not be as permanent in England as in Italy. But until we rid London from the poison of smoke, Fresco painting can never be practised with security.

Now let me briefly pass on to the effect of coal smoke on marble and bronze. Marble is poisoned by it and rendered powdery, the same action of the greasy residuum which we have noticed as applied to paintings acts upon the surface of the marble. The absolutely priceless Greek, Assyrian, and Egyptian works of sculpture in the British Museum are slowly but surely decaying. That exquisite "surface" so dear to the craftsmen of old is fast becoming granular. Washing in the water is of little use; water will not remove the essential oil deposited by poisonous smuts. Glass will protect the surfaces in a measure if it is hermetically sealed so that poison cannot enter. Precious manuscripts are liable to the same deterioration. Bronze is easier to tackle with, because bronze can be cleaned with a solvent; but even here we are in difficulties, because the "surface" of the bronze upon which is dependent so much of its beauty is eaten into by the poisonous particles. All metals, even gold, are similarly injured.

Stone decays under the same causes; upon the lintels of windows inside as well as outside St. Paul's Cathedral is deposited in places a thick layer of solid smoke, sulphur and what not, and this layer is constantly active, it is alive with acid which is devouring the stone and causing it to decay into powder.

Now does this matter, that is the question. Our National Gallery is worth millions of money, our British Museum and South Kensington are likewise worth millions, this is obvious; but private collections in London and in other dirty cities are also priceless; putting the matter upon the lowest ground of commercial interest, I ask, is it wise to risk a certainty of destruction which must come sooner or later if public opinion does not *push* and by unanimity force that impenetrable Talking House to legislate firmly and surely. Royal Commissions do not go for much, they appear rather to feed the inactivity of our legislators than urge them to something certain and practical. Too much discussion sometimes ends in smoke in the sacred walls of Westminster.

Pressure from the *outside* is the only chance for reform in our Army as well as of other grave matters. Public opinion when once it becomes unanimous is the government, and that is the use of democracy. How to set about to wake up a sleeping body except by exposing its inertia and stimulating it to waken up by jogging it constantly it is not for me to say, but I gather that to-day we may consider how far some conclusive Bill may be brought before Parliament to at least minimise a nuisance almost if not entirely unnecessary and certainly, again speaking of commercial interest, excessively expensive.

But in offering a Bill to Parliament we must watch it with the eye of a lynx lest it be pruned down by sophistry and weakened at every point to provide possible loop holes of exit for persistent offenders.

In conclusion, I wish this conference success; unity is strength, and now that the Coal Smoke Abatement Society and The Royal Sanitary Institute have joined hands I fully believe that the voice of the country, both through the Press, the organ of democracy, and among individuals, will rise in volume and give its sanction to some scheme of legislation by which the 20 per cent. of smoke in our fogs shall become a matter of "the past."

A PLEA FOR A SYSTEMATIC COMPARATIVE ANALYSIS OF THE AIR OF TOWNS AND A CONSOLIDATION OF THE LAW DEALING WITH SMOKE EMISSIONS.

By Sir JOHN URE PRIMROSE, Bart.

I HAD the honour of commenting on the important problem of Smoke Pollution and its Abatement, before the Municipal Conference at the Congress held by the Institute in Glasgow in July, 1904, and I thank the Council for again permitting me to explain my views before this important Conference. Although not a technical expert, I may, as a past municipal administrator, be able to make some practical suggestions, which, if persistently followed up and pressed by such influential bodies as your Institute and the Coal Smoke Abatement Society, shall finally result in the reduction of our serious aërial contaminations. Glasgow, the city I represent, has the reputation of being a smoky town. Every stranger has a fling at her for three things, her variable climate, her offensive river, and her smoke-laden atmosphere. We cannot alter the first; the second will soon be a thing of the past; and of the third, I submit, the said stranger can have little relative knowledge. We do not plead guilty to being a smoky city, because guilt in this case must be comparative.

The atmosphere of a manufacturing town cannot be fairly compared with that of a purely residential town, still less with the air of a country village or hamlet. Three standards seem necessary to be established before any one is entitled to say that inhabitants are unduly suffering in health or in amenity from a smoke-polluted air. Although we already possess standards for many things, such as sewage and manufacturers' effluents, acid and other noxious exhalations from works classed under the Alkali Acts, the amount of water and fat in milk, the quantity of butter in margarine, the quality of drugs and such like: we have not yet arrived at even the serious consideration of a suitable standard for city or town air. Air, in which

we are, so to speak, bathed (submerged from morning till night) and in which "we live and move and have our being," may be anything so long as it can be breathed at all, with the exception I have named (the provisions of the Alkali Acts) and excepting also the public health provisions as to "unwholesome trades," when local by-laws can prohibit noxious contamination of the atmosphere. In each of these instances the sense of smell is offended, and the nuisance is palpable. But with a smoke-laden air this is not the case to any serious extent, except when fog is also present. Yet we have abundant evidence that a smoky atmosphere is inimical to health, conducive to depression, and destructive of plant life, as well as of building material.

In the face of experience, we ask "Why is there no standard for towns in regard to smoke pollution?" The answer seems to be that town-dwellers are ignorant of the extent of the pollution, and sanitarians and scientific men have not yet made continued investigations in the cities with a view to enlighten them.

It is true we have had many Conferences, exhibitions of mechanical and other apparatus for the prevention and modification of smoke in steam, boiler, and other furnaces; but I am acquainted with only one serious, sustained, and systematic effort by a thoroughly scientific man to bring the subject home to the public in a comprehensive and lucid manner. I refer to the work of Dr. Angus Smith on "Air and Rain." His investigations were mostly confined to Manchester and district, and similar ones should be instituted in every town of any importance in the United Kingdom, as no one at present knows how London compares with Liverpool, or Birmingham with Glasgow.

That sorrow-inspiring book, "The People of the Abyss," refers on page 44 to some calculations made by Sir William Thistleton-Dyer, on the smoke pollution of the air of London, and on these calculations London is in a worse position than Glasgow. It appears "*from his study of the smoke deposits on the vegetation, that six tons of solid matter, consisting of soot and tarry hydro-carbons, are deposited every week on every quarter of a square mile in and about London*," or 39·66 cwts. per annum on each acre. In Glasgow for the past three years the chief sanitary inspector, who is responsible for the abatement of the smoke nuisance, has kept dust-gauges on the roofs about 30 feet above the street level for 100 days, in each of the 25 wards of the city, submitting the contents for analysis to the corporation analyst. At the 1904 meeting of the Institute in Glasgow, I submitted a table showing the results of these analyses of exposures

from the 1st of March until the 8th of June, whence it appeared that in the spring months the smut-fall averaged 22·119 cwts. per acre per annum. From the 1st November, 1904, to the 8th February, 1905, there is an increase over the previous test of 4·53 cwts. per acre per annum, or 25·649 cwts. as against 22·119. The *mineral matter* is not higher, most of the increase being due to the "*organic matter not soluble in ether*," or, in other words, the pure soot, while it is stated that the most deleterious and defacing agent is the *grease*, or, as expressed in the table, the "*ether-soluble hydro-carbons*," an oily matter of a dark brown colour, known only too well in damp, foggy weather, by the feeling experienced beneath the feet, as if barrels of oil had been smeared over the pavements.

Parallel to this "smut-fall in Glasgow" in spring and winter, I desiderate that similar experiments be made in London and the large towns in order (1) that notes may be compared, (2) that the education of the public may proceed on exact and scientific lines, and (3) that some reasonable standard may finally be adopted for a town's air, beyond which pollution may be considered flagrant and reprehensible. At present information under this heading is in a chaotic state. To know the amount of solid particles in the air of any town from year to year, and at different periods is, I hold, most important, also to know periodically the constituents which are thrown down by a day's rain. Ammoniacal, nitrous, sulphurous, carbonic and other vapours and gases are continually rising from a city to pollute its atmosphere, and obtaining a collection of dust in gauges does not enable us to ascertain the nature or amount of the gaseous and volatile impurities. Hence on wet days as much of the rain as possible should be caught in various parts of a city, and submitted, while fresh, to analysis. Angus Smith's experiments in this way indicated an appreciable amount of free acid in the air of towns.

The same method has been recently practised in Glasgow. On the 26th of October, 1905, ten wooden boxes, in groups of two, were placed in the centre of each main division of the city, on roofs about 30 feet above the street-level and beyond interference. Rain fell all day heavily; consequently, sufficient water was collected for a satisfactory analysis. The analyst found no trace of free acid, showing that, whatever may have been the case in Dr. Angus Smith's day, we are apparently now free from the irritating acid vapours which used to escape unhindered from the alkali and kindred manufactories. This is a most important fact, and it would be well if it could be corroborated or assailed by similar experiments in other towns.

It may be explained that this box was mounted on a roof practically in the centre of the cattle market and public abattoir of the city, where the air is certain to be impregnated with organic vapours from the bodies of the animals, from cattle-lairs, pens and slaughter-houses, and the figures given by the public analyst are only what might be anticipated by common sense. The solids in suspension, which may be taken to represent fairly the smokiness of the locality, are not in appreciable excess compared with the others.

As to the consolidation of the law dealing with smoke emissions, the most casual glance at the various Acts of Parliament under which municipal authorities are now working shows the disparity that exists between them.

Speaking generally, all but one of the Acts appear to give power to abate the smoke nuisance, and then, by the use of certain limiting expressions, permit a loophole of escape. Section 23 of the Public Health (London) Act, 1891, is a good example of this. Sub-section (4) seems to emasculate the powers previously conferred by enacting that "the words "consume or burn the smoke" shall not be held in all cases to mean "consume or burn all the smoke;" and the court hearing an information against a person may remit the fine, if of opinion that such person has so constructed his furnace as to consume or burn, *as far as possible*, all the smoke arising from such furnace, and has carefully attended to the same, and consumed or burned, *as far as possible*, the smoke arising from such furnace."

A Glasgow deputation, which came to London in 1904 on this subject, were informed by Mr. Alfred Spencer, of the London County General Purposes Department, that this section, and Section 24 (*a*) of the Act were "so crippled by those qualifying words that it was very difficult to obtain convictions under them, and consequently they were not used," and the London sanitary authorities had to issue their complaints under Section 24 (*b*), which runs: "Any chimney (not being the chimney of a private dwelling-house) sending forth *black smoke* in such quantities as to be a nuisance."

In face of such a statement as this, further criticism may well be considered needless; but as all law is supposed to be based on common-sense, we are bound to inquire whether a furnace, properly constructed and carefully attended to, may yet produce black smoke or any smoke. If the answer to this question be yes, then the limiting words are necessary to protect innocent people. If the answer be no, then the limiting words

should be struck out, and the issue of smoke from any steam-boiler or such-like furnace made absolutely a contravention. Whether yes or no is the correct answer here, I would prefer to leave to the engineering and mechanical experts. My experience as a manufacturer would lead me to answer no, as I have been able, by the appliances in my own boiler furnaces, to work them day and night without any smoke. Moreover, it has to be borne in mind that a furnace may be perfectly constructed, and properly managed and fired, and yet cause smoke from two causes not noted in any of the Acts, viz.: (*a*) insufficient draught, and (*b*) the use of a low-class bituminous fuel.

The first defect may be caused by defective flues or a defective chimney, neither of which, so far as I am aware, comes under the definition of the word "furnace." In either of these cases a person may quite easily prove he had excellent furnaces, up-to-date in every respect, and that his fireman fired them in a manner above reproach, and yet smoke was the result; in which case, under Acts framed in this way, he would escape conviction.

Our Act in Glasgow, although perhaps not an ideal one, avoids this mistake by making it compulsory upon a respondent to prove, not only that he has constructed his furnaces so as, as far as possible, to consume the smoke, and carefully attended to and managed them in a proper manner, but also "that he has used the best practicable means for preventing smoke," thus covering defects in chimney, flues, or any other part of his steam-raising or heating installation. True, nothing is said as to the quality of the fuel, but, in my opinion, no person should be permitted to burn a low class and smoky dross or slack in any furnace, no matter how perfectly constructed or how well fired, and escape the meshes of the law if the result is black smoke.

I said at the beginning of this part of my paper that there was one exception to this unsatisfactory state of the law. Every town but Nottingham suffers more or less from the qualifying words I have alluded to. In this town the law seems to be simple and perfect. Permit me to read to you Section 76 of the Nottingham Improvement Act of 1874. It is in the following terms:—

> "76. For prevention of smoke, the following provisions shall have effect (that is to say):
>
> 1. If any fireplace or furnace employed, after the commencement of this Act, in the working of engines by steam, or in any building used for the purpose of trade or manufacture, or baths or wash-houses (although a steam-engine is not used therein) is not so constructed as to prevent or burn the smoke arising from such fireplace or furnace, the owner or occu-

pier of the building or lands in or on which such fireplace or furnace is situate shall be liable to a penalty not exceeding ten pounds, and to a further penalty not exceeding forty shillings for every day during any part of which any fireplace or furnace is so employed without being constructed so as to prevent or burn the smoke arising therefrom:

2. If any such owner or occupier, after the commencement of this Act, negligently uses, or permits to be used, any fireplace or furnace so constructed as to prevent or burn the smoke arising therefrom in such manner that the smoke arising therefrom is not effectually prevented or burnt, he shall be liable to a penalty not exceeding ten pounds, and to a further penalty not exceeding forty shillings for every day during any part of which such fireplace or furnace is so continued to be used:

3. If any engineer, fireman, stoker, foreman, or other person negligently uses any fireplace or furnace constructed so as to prevent or burn the smoke arising therefrom in such manner that the smoke arising therefrom is not effectually prevented or burnt, he shall be liable to a penalty not exceeding forty shillings:

4. The foregoing provisions of this section shall extend to cases where more fireplaces or furnaces than one communicate with a single chimney, and in any such case the names of the several owners and occupiers of the buildings or lands on which they are situate, and the several engineers, firemen, stokers, foremen, or other persons having the control or management thereof, may be included in one summons, and the justice before whom the case is brought may, in his discretion, apportion the penalty as he sees fit, or impose a penalty on one or more of those persons in exclusion of the others:

5. If any such owner or occupier, or the servant of either of them, refuses to allow such building or lands to be inspected by a person authorised by the Corporation, then any person so authorised may, by warrant under the hand of a justice (which warrant any justice is hereby authorised to grant) enter into and upon such building or lands, and examine any such fireplace or furnace."

Here we have no qualifications nor limitations. Moreover, under Subsection (3), the stoker or fireman may be the convicted party and not the master or firm, which appears to me to be perfectly just, and on all fours with the terms of the Alkali Act, by which, if the issue of acid vapours be in excess of what is prescribed, the careless employee is made responsible, if in the opinion of the inspector, the apparatus of the manufacturer is in perfect order.

I am informed by the Chief Sanitary Inspector of Glasgow that over 90 per cent. of the complaints of excessive smoke taken against manufacturing firms there, are caused by careless firing on the part of the stokers. Such a state of matters calls for reform. I can see no essential difference between the careless issue of acid vapours from perfect machinery in a work classed under the Alkali Act, and the careless issue

of smoke from properly constructed furnaces attached to suitable flues and an adequate chimney.

I now leave the discussion in your hands. The law, to my mind, is deficient as it stands at present. It needs amendment, but it also needs consolidating. The manufacturers in one town should in this respect be placed in an equal position with the manufacturers in every other town; otherwise legislation against this evil will be partial, wanting in precision, and will operate unequally and unfairly. I trust this important Conference will help to bring about both amendment and consolidation of the law, and to this end I plead for a systematic and persistent education of public opinion, both by The Royal Sanitary Institute and the various important local authorities throughout the country.

NOTE ON

THE PROPOSED AMENDMENT OF SEC. 24 (SUB-SEC. 6), OF THE PUBLIC HEALTH (LONDON) ACT, 1891.

By JULIAN S. CORBETT, LL.M., F.S.A.,
Barrister-at-Law.

THE wording of this section has always been a stumbling block. Difficulties have constantly occurred in proving that the smoke complained of was "black." As a matter of optics no smoke in daylight can be "black," and therefore it is clear that the section contemplates smoke of a density which more or less nearly approaches "black." Here then at once arises an uncertain factor, and in each case a successful prosecution depends upon what degree of density will in the opinion of the particular magistrate satisfy the legislative conception of "black." Municipal inspectors are equally human, and no means exists of defining the word "black" in such a way as would be binding upon either of them except by Act of Parliament, and it follows that the administration of the law must remain in this difficult, uncertain, and cumbrous condition until the section in question is amended.

A further reason which makes such an amendment highly desirable is that apart from smoke which more or less nearly approximates to "black," great quantities of noxious smoke are emitted which cannot by any stretch of words be called "black," and which yet is as noisome and offensive as the densest.

Under these circumstances the Corporation of the City of Westminster, a body which has always been in the forefront of efficient administration in this matter, proposed, in a circular to the Metropolitan Borough Councils, an amendment of the section which they might all agree to advocate. The proposal was to delete the word "black" from the section altogether. On the proposal being brought to the notice of the Coal Smoke Abatement Society, it was observed that, excellent as it was to meet part of the existing difficulty, it tended to raise new difficulties in a large class of

cases where at present they do not exist. To delete the word "black" simply, and merely forbid smoke that was a nuisance, would involve the proving in every case that the smoke complained of was of such a character as to amount to a nuisance, always a difficult proceeding. It would no longer be possible to secure a conviction merely by proving the smoke was approximately black, and these are the commonest and most noxious cases. The Society therefore suggested that the words "black smoke" should be retained, and the words "or smoke" inserted immediately after them. By this amendment the section would read "black smoke or smoke in such a quantity as to be a nuisance." In this way would be retained all the summary advantage of the old wording, added to the possibility of putting a stop to smoke which, though in no sense "black," was dense enough to be a nuisance and amount to pollution of the air.

This suggestion appears to have met generally with the approval of the authorities concerned, and it is to be hoped that at the next amendment of the Public Health Act the section in question will be modified on these lines.

It by no means follows, however, that the section so amended will be in the best conceivable form. All that can be claimed for it is that it will be well abreast of English public opinion on the subject, and will go as far towards a complete suppression of the nuisance as is at present likely to be practicable. Still there are possibilities beyond what appear to be immediately practicable. Since the amendment of the section was considered, as above related, the Foreign Office at the instance of the Society has collected and issued a series of reports on smoke legislation abroad, and considerable new light is thrown on the possibilities of the question.

On the whole it would appear that, bad as we are, we stand far ahead of the majority of foreign countries. In most of these no legislation exists at all. In France, for instance, no general law has been adopted, while all the old attempts to stop smoke pollution in Paris by police "Ordonnance" failed against passive resistance. The latest one appears to have fared no better. It was of a most modest character, for it went no further than to forbid the "prolonged emission of thick black smoke," *(interdit de produire une fumée noire épaisse et prolongée)*, but even this appears to be little better than a dead letter. Germany, too, has shrunk from making any general law, and does not even venture so far as France in the Paris ordonnance. The German Government goes no further than to order that "care should be taken *in all works under State control* that

the emission of *black, thick and continuous smoke* be avoided, in the first instance, by expert management of fires, proper supervision of firemen, and careful selection of fuel."

Thus we see that in these two countries the standard of atmospheric purity aimed at is considerably lower than with us under the Act as it stands.

In Dresden, however, a city which has long been noted as an example of amenity in civic management, we find that as far back as 1887 a by-law was enacted which goes beyond anything we have ventured even to propose in London, or elsewhere in the three kingdoms. It runs thus:—"In all manufacturing and industrial premises the construction of the furnaces must be of such a nature and their stoking so regulated that *no smoke containing visible particles of soot* is constantly emitted." "Where this happens only occasionally and exceptionally, the nuisance must not last longer than is absolutely unavoidable even with the most careful stoking and the employment of coal of at least medium quality."

Two years were given as a period of grace to existing premises. But the Dresden authorities were not content even with this drastic dealing with industrial premises. They extended their hand against private premises as well; and the by-law further provided that "In private dwelling houses the heating arrangement must be so contrived as to produce as little smoke as possible."

To forbid black smoke absolutely, and coloured (visible) smoke almost entirely, appears to go very far, but the step was taken not unsympathetically. At the same time an official inspector was appointed, whose duties were not only to enforce the law, but to assist citizens in complying with it. Besides reporting offending premises, he was to hear all complaints against "the practicability and onerous nature of the by-laws." He was to inquire into and suggest improvements in means for combating smoke, and he had attached to him an expert foreman stoker, who assists him in his duties and "is frequently called on to give practical illustration of the effect of skilful stoking in reducing smoke."

In these admirable and highly practical provisions we seem to get a new note in legislation which is worthy of the fullest consideration. The serious opposition to any extension of the law comes from manufacturers who plead in perfect good faith, and with convincing earnestness, that any further restrictions in smoke production are incompatible with London remaining a manufacturing city. On this point, however, there is no certainty. Many competent authorities share the belief of the German Government that by well-constructed furnaces, reasonably good fuel, and

above all, by skilful stoking, the evil would practically disappear without crippling the industries concerned. The methods they recommend are in themselves methods of ensuring economy, and were State assistance provided to explain and bring home to manufacturers how such economies could be effected, there seems no doubt that the bulk of the opposition would be removed. The hint, therefore, that we get from Dresden is that if we wish to get really efficient legislation carried through, it is highly desirable to accompany it with some provision for securing to manufacturers gratuitous instruction for stokers, and gratuitous advice on the general management of their fires. This at least appears to be the policy on which Dresden has been proceeding with so much success.

It remains to notice certain amendments suggested by American legislation. For though that country as a whole is far behind Dresden in the matter, some excellent provisions have been adopted by Philadelphia, Chicago and Massachusetts.

In Philadelphia there is an ordinance to regulate smoke from chimneys, which incorporates a colour scale for the measurement of the density and darkness of smoke; and within the limits of the city it is forbidden to emit smoke of a degree of darkness in excess of scale No. 2 for a period of more than five consecutive minutes from any locomotive or steamboat; while with regard to factories, etc., the scale of colour varies with the height of the chimney. The Chicago ordinance simply forbids the emission of "dense smoke," with a time-limit of three minutes.

Massachusetts appears to be the only State that has adopted a general Act. Section 1 of the Act of 1901 forbids as a nuisance the emission of "dark smoke or dense grey smoke for more than four minutes continuously, or for 12 per cent. of any continuous period of twelve hours."

It will be seen that the American legislature attaches importance to a time-period, that is, to having a minimum period during which the emission of objectionable smoke is permitted as unavoidable. No such period of grace has been enacted in this country, but in practice it is allowed. The length of such period differs in various places, and with various magistrates, just as does the interpretation of the word "black," and it would undoubtedly add certainty, and therefore efficient administration to the law, if we were to adopt, in amending our Act, some such time-limit as has commended itself to American experience.

ENGLISH LAW RELATING TO THE EMISSION OF SMOKE FROM CHIMNEYS.

By JOSEPH HURST.

Barrister-at-Law.

THE emission of smoke from chimneys may be dealt with under English law in the following cases:—

(1) Throughout England where that emission is a nuisance at common law;

(2) Throughout England (except London) where that emission offends against the provisions of the Public Health Act, 1875, or against similar provisions in local Acts;

(3) In London where that emission offends against the provisions of the Public Health (London) Act, 1891.

I propose to deal very shortly with (1) for, speaking generally, it will be found that readier and easier means of abatement exist under (2) or (3) than under (1).

As, however, there are sometimes occasions when considerable damage has already been caused, or when it is desired to restrain for the future a serious emission of smoke which, if allowed to continue, would be injurious to public or private health or property, I will state shortly the law relating to (1).

To constitute a nuisance *at common law* by reason of the emission of smoke there must exist (*a*) injury to health; or (*b*) injury to public or private property; or (*c*) personal discomfort to individuals.

If it be desired to protect public health, or public property, or to prevent general discomfort, the law must, in most instances, be invoked by the Attorney General, as representing the public; his action is generally (though not always) set in motion at the instance, or relation, of a public body, or of individuals.

Where, however, an individual is likely to sustain or has sustained injury to his health or property, or personal discomfort by reason of the

emission of smoke, he may himself invoke the law with respect to nuisance, by bringing an action for injunction to prevent the happening of the nuisance, or to prevent its recurrence, or to recover damages as compensation for that which has already occurred to him or his property by reason of the nuisance.

But whether the law be invoked by the Attorney General, as representing the public and its interests, or by an individual for his own protection or compensation, it will be necessary, in either case, to establish that a nuisance (as defined above) will probably be, or has been, created by the emission of smoke.

For the purpose of so doing it is not necessary to make out that black smoke (as under the Public Health Acts referred to above) or smoke of any shade, density, or quality, is likely to be, or has been, issued. It will be enough to establish that a nuisance (as defined above) is likely to occur, or has occurred, from the issue of smoke or vapour, or smells from a factory or other chimney, whether the latter be the chimney of a private dwelling house or not.

But what may be an actionable nuisance, even in this sense, is not capable of precise definition, applicable to all circumstances, or to all localities. This may be learned by a perusal of the Judgment of the late Lord Chief Baron Pollock, in the case of *Bamford* v. *Turnley* (31 L. J Q. B., 292) where with the precision and freshness of language which always distinguished him, he said :—

> "The question so entirely depends on the surrounding circumstances —the place where—the time when—the alleged nuisance, what—the mode of committing it, how—and the duration of it, whether temporary or permanent, occasional or continual—as to make it impossible to lay down any rule of law applicable to every case, and which will be also useful in assisting a jury to come to a satisfactory conclusion. It must at all times be a question of fact with reference to all the circumstances of the case. Most certainly, in my judgment, it cannot be laid down as a legal proposition, or doctrine, that anything which, under any circumstances, lessens the comfort or endangers the health or safety of a neighbour, must *necessarily* be an objectionable nuisance. That may be a nuisance in Grosvenor Square which would be none in Smithfield Market. That may be a nuisance at mid-day which would not be a nuisance at midnight. That may be a nuisance which is permanent and continual, which would be no nuisance if temporary or occasional only. A clock striking the hour, or a bell ringing for some domestic purpose may be a nuisance if unreasonably loud and discordant, of which the jury alone must judge ; but although not unreasonably loud, if the owner, from some whim or caprice, made the clock strike the hour every ten minutes, or the bell ring continually, I think a jury would be justified in considering it to be a very great nuisance. In general a kitchen chimney, suitable to the establishment to which it

> belonged, could not be deemed a nuisance, but if built in an inconvenient place or manner, on purpose to annoy the neighbours, it might very properly be treated as one."

To this example I would venture to add that of a kitchen chimney improperly used with reference to fuel consumed, or otherwise, whereby large quantities of smoke were emitted for long intervals of time. He proceeds—

> "The compromises that belong to social life, and upon which the peace and comfort of it mainly depend, will furnish an indefinite number of examples in which some apparent natural right is invaded, or some enjoyment abridged, to provide for the more general convenience or necessities of the whole community."

The above views were expressed in an action successfully brought in respect of nuisance arising from brick burning.

Smoke, unaccompanied by noise or by noxious vapour, noise alone, and offensive odours alone, although not injurious to health, may severally constitute a nuisance. The material question in all cases is, whether the annoyance produced is such as materially to interfere with the ordinary comfort of human existence. Hence an injunction was granted to restrain the issuing of smoke and effluvia from a factory chimney, and the making of noise in the factory, although it was situated in a manufacturing town, it being proved that such smoke, effluvia and noise were a material addition to previously existing nuisances. (Crump *v.* Lambert, L.R. 3 Eq. 409; affirmed on appeal, 17 *Law Times* N.S. 133.)

Public Health Act, 1875.

From attempts to define what is an actionable nuisance, and from discussions of what is the appropriate proceeding when a common law nuisance is threatened or exists, it is encouraging to those who are earnest in the promotion of public health to turn to the plain language of the smoke sections of the Public Health Acts, referred to above, under which health and property are generally (although, I fear, with many exceptions) effectively protected.

The Public Health Act, 1875, contains the statutory law as to the emission of smoke throughout England, except in London, and except in a few provincial cities and towns governed by local Acts.

Public Health (London) Act, 1891.

The provisions of this Act relating to smoke nuisance are practically (with some extensions) the same as those in the Act of 1875, already set out at some length. But since the Act of 1875 does not (with some

slight exceptions) apply to London, the smoke sections have been included in the Act of 1891, so as to be applicable to the Metropolis within "the administrative County of London."

The sanitary authorities within the London area are the Corporation of London and the city and borough councils.

In practice it is found in case of neglect of duty by the sanitary authority (excepting the Corporation of London) that a representation to the London County Council secures the abatement of a nuisance, or, at any rate, due attention to the matter.

It will be observed that up to the present time no legislation has been attempted with the view of minimising smoke from domestic kitcheners or grates. The height of buildings, etc., affecting the access of light and air have been the subject of drastic enactments; but the domestic kitchener or grate, which by the smoke it sends forth enormously affects light and air, has, so far as legislation is concerned, been left to work "its own sweet will." This seems inconsistent with the principle which one would assume underlies legislation, under which domestic appliances in connection with water, gas, electric current, etc., have been the subject of jealous regard, and are the objects of frequent domiciliary visits even in the neighbourhood of the domestic hearth. It is to be hoped that as a result of the inquiries now being carried on by the Coal Smoke Abatement Society, with the assistance of the Office of Works and others, a domestic grate may be discovered which shall, by improved combustion, prevent, at least, black smoke. When such a grate is discovered, legislation will be not only desirable but opportune, by which there may be secured to the consumer more beneficial use of fuel, and to the Metropolis and to large provincial cities and towns brighter and cleaner atmospheres.

REPORT UPON RETURNS FURNISHED BY LOCAL AUTHORITIES WITH REGARD TO THE CARRYING OUT OF THEIR

POWERS & DUTIES IN THE MATTER OF SMOKE ABATEMENT.

By LAWRENCE W. CHUBB, F.C.I.S.,

Secretary, Coal Smoke Abatement Society.

WITH the object of ascertaining to what extent local authorities have grappled with the problem of smoke abatement, all corporations and urban district councils in the United Kingdom have been asked to furnish replies to a series of questions addressed to them on behalf of The Royal Sanitary Institute and the Coal Smoke Abatement Society.

In all, 205 authorities have complied with the request, and from the answers supplied a considerable amount of interesting information may be extracted. While it is true that a feeling of indifference or hopelessness is manifested by a minority of the sanitary authorities, on the whole the reports show that where a local authority resolutely faces the subject of smoke abatement, with a determination to enforce the provisions of the Public Health Acts, it does not often experience insuperable difficulties in minimising, if not in entirely suppressing, black smoke nuisances. At the same time there is a general consensus of opinion that the law should be materially simplified and strengthened.

Indifference of certain Local Authorities.

Of the 205 reports, those received from county councils do not call for special comment, as such councils do not possess urban sanitary powers. Thirty other reports may be summarily dismissed, for the authorities confess that they have either entirely neglected the matter, or that the smoke evil has not been sufficiently acute in their area to demand attention. It is

fair, perhaps, to infer that the many authorities from whom no returns have been received should be placed in the same category. The authorities whose reports may be dismissed as being negative in character are those for the following places: Abertillery, Carnarvon, Colchester, Crewe, Darlington, Devonport, Doncaster, Dover, Dunfermline, Exeter, Harwich, Hereford, Ilford, Ilkeston, Kesteven C.C., Leamington Spa, Llanelly, Maidstone, Oldbury, Reigate, Rochester, St. Albans, Shrewsbury, South Shields, Tipton, Wednesbury, West Bromwich, Wokington, and Woodford.

The inactivity on the part of some of the councils named is evidently due to a fundamental misconception of the subject. The excuse given on behalf of Tipton may be cited as a typical illustration of this assumption. It is said on their behalf that the "council will not take any steps in the matter as they are too glad to have the smoke as an evidence of renewed trade." If every sanitary authority could be brought to recognise that the emission of black smoke is an ocular proof of an avoidable waste of fuel which, as has been abundantly demonstrated, can be remedied to the pecuniary advantage of the employer, as well as to the comfort of the public, they might, perhaps, realise the desirability, from all points of view, of performing their statutory duties in the matter.

It is refreshing to turn from the councils which have displayed no interest in the subject to those which manifest a keen sense of their obligations to the public.

LOCAL AUTHORITIES HAVING SPECIAL SMOKE INSPECTORS.

The following authorities state that they employ special inspectors with the object of dealing with smoke nuisances:—Bethnal Green, Birmingham (4 each), Bradford, Croydon, Edinburgh, Glasgow (2 each), Hackney, Hammersmith, Hull, King's Lynn, Lambeth, Leeds, Liverpool (3 each), City of London, London County Council (5 each), Manchester (5, one being a chemist in whose duties is included the inspection of chemical and other works where chemical or expert knowledge is required), Marylebone, Paddington, Stockport, Salford, Sheffield, and West Ham also have special smoke inspectors.

In other cases the sanitary officers or inspectors of nuisances are instructed to deal with nuisances arising from the emission of black smoke.

POLICE ASSISTANCE.

The services of the police are utilised by the following authorities:—Alfreton, Ayr, Battersea (occasionally), Bury (where a policeman accompanies an inspector making observations), Cambridge, Devonport, Dun-

fermline, Edinburgh, Gloucester, Gorton, Greenwich (occasionally), City of London (when required), Manchester (casually), Margate, Merthyr Tydfil, Nottingham (police only), Paddington, Paisley (police only), Ramsgate (police only), and Southport (police only).

In the case of Nottingham the co-operation of the police has evidently been of much service, for the corporation recommend an alteration of the law, so that it shall be a special duty of the police to take proceedings in all cases of emission of black smoke.

Time Limits for the Emission of Smoke.

One of the questions addressed to local authorities was:—"Has any hourly or other limit been fixed during which black smoke may be emitted from factories or other works within the area controlled by the corporation?" The Public Health Acts do not define what constitutes a black smoke nuisance. They simply indicate that, where black smoke is emitted in such quantities as to be a nuisance, the nuisance shall be liable to be dealt with summarily under the Acts. It is open to doubt whether any imposition of a time-limit during which black smoke might be emitted with impunity, would be desirable. Nevertheless, it must be admitted that the present state of the law has led to a great deal of confusion, for each authority itself defines what, in its opinion, constitutes a black smoke nuisance, and glaring anomalies naturally exist. For instance, at Leeds the emission of black smoke for an aggregate period of three minutes in an hour is held to be sufficient to justify action, whereas at Middlesborough the period is fixed at fifteen minutes, and at Perth the emission must be *continuous* for eight minutes.

Several authorities have expressed an opinion that the fixing of a time-limit would be both illegal and unwise, but on the other hand a large number point out that it would be far less difficult to obtain a conviction were a fixed time-limit imposed than is the case at the present time, when Magistrates have their own views as to what constitutes a black smoke nuisance.

Increase or Decrease of Smoke.

145 Councils have answered the question "In the opinion of the authority is the emission of black smoke increasing or decreasing within its area?" 25 have replied that an increase has taken place; 80 have stated that in their judgment the evil shows a tendency to decrease, often due to the substitution of gas for steam power; while 40 stated that the nuisance remains stationary.

ACTION TAKEN BY LOCAL AUTHORITIES.

Councils were asked to state how many smoke nuisances were reported to them during each of the last two years, how many statutory notices were served by them, and the number of prosecutions undertaken. The information supplied on these points is too inadequate to permit of detailed and satisfactory analysis.

The incomplete returns furnished by 23 Metropolitan Borough Councils show that 4,353 reports of smoke nuisances were dealt with during the last two years, 897 statutory and 394 intimation notices being served and 61 prosecutions undertaken.

The returns furnished by 109 provincial authorities are also incomplete. So far as they may be relied upon, however, they show that during the last two years 9,553 smoke nuisances have been reported to the 109 councils; these have led to the issue of 4,059 intimation and statutory notices and to 2,345 prosecutions.

The information with regard to prosecutions undertaken by provincial authorities is misleading, for seven of the authorities are responsible for no fewer than 2,181 of the proceedings, leaving only 164 prosecutions undertaken in two years by the remaining 102 authorities. The city of Liverpool, which moves under a special local Act and not under the Public Health Act, 1875, undertook 643 prosecutions in 1903 and 615 in 1904, being successful in 633 and 602 cases respectively and receiving in fines £2,466 12s. 2d., an average of about £2 per case. Of the other authorities, Manchester initiated 277 cases, Glasgow 226, Birmingham 178, Bradford 111, Nottingham 69 and Sheffield 62.

One of the most disquieting features manifested by the information supplied under this head is the small percentage of cases in which statutory notices have been served and subsequent proceedings initiated by local authorities. In the provinces, after deducting the cases dealt with by the 7 authorities referred to in the preceding paragraph, there still remain 6,182 reports of black smoke nuisances. In 2,087 instances letters of caution or statutory notices have been served, and apparently the letters of caution far exceed the statutory notices in number. Only 164 prosecutions were undertaken. In the Metropolis only 897 statutory and 394 intimation notices were issued in respect of 4,355 cases and the prosecutions amounted to 61. It is obvious that if local authorities do not follow up reports of smoke nuisances by serving statutory notices and initiating legal proceedings the nuisances are not likely to be abated. Several councils state, in extenuation of their inaction, that it is hopeless to secure

a conviction as the members of the Bench adjudicating are themselves often offenders in the matter of smoke nuisances!

Smoke Nuisances in adjoining Districts.

A considerable number of local authorities complain of black smoke nuisances arising in the area of adjoining authorities, but the only councils which appear to have moved in such cases, either by written complaints, by serving statutory notices, or by initiating proceedings, are Batley, Brighton, Ealing, Enfield, Hammersmith, Huddersfield, Kensington, Lancaster, the City of London, Manchester, Salford, Shoreditch, Stretford, Stroud, Swinton and Pendlebury, and Westminster.

Methods of Identification of Black Smoke.

In order to ascertain the means adopted for the identification of black smoke, local authorities were asked: "Is any standard or scale used to identify the density of smoke? If not, what method of scheduling or identification is adopted?" The replies disclose that the general rule is to permit the inspectors taking observations to act upon their own judgment. Most of the important corporations provide their officers with special sheets on which to record, in graduated columns, the density of smoke emitted, and in some cases observations are made jointly by two inspectors. The following authorities treat as black all smoke which cannot be seen through when it emerges from the chimney: Ashton-under-Lyne, Blackburn, Bury, Chorley, Epsom, Farnworth, Halifax, Heywood, Oldham, Preston, Rochdale, St. Helens, Southampton and Stretford. Eccles, Liverpool and Newcastle-on-Tyne consider smoke black when it is opaque after it has travelled a few yards; Huddersfield and Norwich when the lightning conductors cannot be seen through it; and Falkirk when the top of the chimney cannot be seen through it. Several authorities supply their officers with sheets illustrating various shades of smoke. Among these, Coventry, St. Marylebone and Willesden use the diagrams issued by the Coal Smoke Abatement Society; Cardiff Hammersmith, Reading and Woolwich use Ringlemann's Smoke Scale, and Bournemouth has adopted the method of identification advocated by Messrs. Sanderson & Clayton. St. Pancras, Battersea, Manchester, the City of London, the London County Council, and the London Port Sanitary Authority have specially prepared and shaded diagrams for the use of their inspectors; and Westminster uses the scale adopted by St. Pancras. Photography is employed, as an accessory to the inspector's

personal observation, by Bradford, Holborn and Hull; and the Glasgow Corporation state: "The term 'black smoke' is defined as smoke containing 281 lbs. of solid matter per million cubic feet discharged, light brown smoke containing only 20 lbs. of solid constituents."

PROPOSED AMENDMENTS OF LAW.

Local authorities were further asked whether, in their opinion, any amendments were needed in the law with regard to the suppression of black smoke nuisances. Fifty-six have expressed no opinion upon the desirability of any change being effected in the law with regard to the abatement of smoke, and only two have indicated their satisfaction with the law as it at present stands. On the other hand this question elicited a number of helpful suggestions, of which the following are perhaps the most useful.

The proposed amendments mainly deal with Clause 91 of the Public Health Act, 1875, the clause which declares a chimney (not being a chimney of a private dwelling house) emitting "black" smoke, to be a nuisance within the meaning of the Act. Owing to the difficulty of obtaining the requisite technical evidence to secure a conviction under the alternative provision of the Act designed to prohibit the use in trade premises of a furnace so constructed as not to consume its own smoke, practically all prosecutions issued by local authorities with the object of securing the suppression of smoke nuisances are taken under the section prohibiting the emission of black smoke.

The following local authorities advocate the omission of the qualifying word "black" from the section, in order to enable proceedings to be instituted in cases where smoke emitted is actually a nuisance though not "black" in colour: Blackpool, Cardiff, Chelsea, Epsom, Lambeth, and Sheffield. The authorities advocating the substitution of the word "dense" for "black," are Keighley, Nelson (or delete "black"), and Stretford (and delete words "as far as practicable").

The Coal Smoke Abatement Society has at various times carefully considered the desirability of amending Section 91 of the Public Health Act, and has come to the conclusion that it would be inadvisable to delete the word "black," as proof of the sustained emission of black smoke is (or should be) at present sufficient to secure a conviction; it has also felt that the substitution of the word "dense" for "black" would only remove one technical difficulty to create another. It, however, has suggested that the section would be materially strengthened if it were broadened to permit of prosecutions in respect of smoke of any colour

emitted in such quantities as to be a nuisance. All that is needed to secure this desirable amendment is the insertion in Section 91 of the Public Health Act, 1875, and in Section 24 (*b*) of the Public Health (London) Act, 1893, after the words "black smoke," of the words "or other smoke." It is interesting to note that this proposal is also made on behalf of Cardiff, Enfield, Greenwich, Hammersmith, Kensington, the London County Council, Paddington, Westminster, and Wood Green. Liverpool suggests the substitution of the words "excessive and unnecessary" for "black."

As has been already indicated, several authorities allude to the difficulty they experience in obtaining a conviction owing to the fact that the Magistrates before whom the proceedings take place are themselves black smoke offenders. They therefore press for the appointment of Stipendiary Magistrates, who might be relied upon to have no personal bias on the question.

The lowness of the penalties imposed upon the conviction of offenders is frequently commented upon, and several authorities urge that the penalties should be materially increased for the first offence and automatically raised on subsequent conviction, in order to make it imperative on the part of the manufacturers to abate smoke nuisances. It is pointed out that where penalties are not sufficiently large to act as a deterrent, offenders prefer to run the risk of further convictions rather than adopt means to abate the emission of smoke. It is also suggested that magistrates should inflict a penalty when an abatement order is issued. On this point the Public Control Committee of the London County Council has recommended the alteration of the law, by the imposition of a direct penalty of not exceeding £10 for the first offence, increasing for subsequent offences, instead of applying to smoke nuisance, as at present, the complicated procedure that may be properly applicable to a sanitary nuisance. Bolton, Bootle, Bradford, Northampton, Salford and Willesden are amongst the other authorities which urge that increased penalties should be provided for.

It is further suggested that Parliament should be invited to fix a definite hourly time-limit for the emission of black smoke, proof of the limit having been exceeded to be sufficient to secure a conviction. The local authorities urging this amendment are those for Dundee, Keighley (four minutes per hour suggested), Kidderminster, Lancaster, Luton (fifteen minutes per hour suggested), Stroud, Tottenham, and Wood Green.

Another interesting proposal is that put forward by the Chelsea Borough Council, on whose behalf it is pointed out that a great deal of

offensive black smoke is emitted from the chimneys of the large mansions and flats in the district. It is suggested that the law should be amended to enable such nuisances to be dealt with.

Other suggestions are that the delay arising from the present complicated procedure, which involves the service of statutory notices, should be obviated by the giving of power to the Medical Officer of Health to summon forthwith on the detection of a nuisance; that the police should be empowered to initiate proceedings; that a definite scale or standard should be provided for the identification of smoke; that firemen should be dealt with and fined when proper appliances and proper coal are found (this is done under a local Act at Nottingham); that factory inspectors should be appointed by a Government department; that the prohibition against the emission of black smoke should be applied to property in possession of the Crown, a proposal adopted at a Conference of Metropolitan Borough Councils, and endorsed by the London County Council; and that provision should be made for the infliction of heavier penalties in cases of black smoke emitted from locomotives on highways or railways.

CONCLUSION.

To sum up, the returns disclose that while the black smoke evil is very generally felt and deplored, relatively few local authorities have in the past taken a decided stand in the matter, and that while this inactivity may sometimes be traced to apathy, it is more often due not to any inclination to evade responsibility, but to a feeling of hopelessness in view of the uncertainty of obtaining convictions. Where authorities have taken a decided stand, however, even with the imperfect machinery at present available for the suppression of smoke nuisances, it is only fair to say that they claim to have diminished the evil. Little improvement or zeal can be looked for until the law is simplified and extended, and a more summary and effective method of procedure provided. It is, perhaps, not too much to hope that the Local Government Board, in view of the suggestions made by important corporations, may see its way to clothe local authorities, in the immediate future, with the further powers for which they ask.

SMOKE ABATEMENT FROM THE SANITARY INSPECTOR'S POINT OF VIEW.

By T. G. DEE,
Sanitary Inspector, City of Westminster.
(A.R.SAN.I.)

THIS paper gives an inspector's point of view of the subject of smoke abatement.

The Public Health (London) Act, 1891, repealed "An Act to Abate Nuisances arising from the Smoke of Furnaces in the Metropolis and from Steam Vessels above London Bridge" (16 and 17 Vict., chap. 128), and thus fixed on sanitary inspectors in the metropolis the duty of reporting, to their several local authorities, nuisances arising from the emission of smoke, which had previously been the joint duty of the police and sanitary officers, and was almost entirely left to the police to carry out. On examining the provisions of the law we found that we had no power over the chimneys of private dwelling houses. We were of the opinion that *any* other chimney sending forth *black* smoke was a reasonably easy matter to deal with, but that the procedure under the section was very slow, and that the maximum penalty (ten pounds), section 4, sub-section 4, not being cumulative, was inadequate to prevent nuisances occurring thereunder. That either magistrates or local authorities were unwilling to close works (note Doulton's) or to deal with them as recurring nuisances (note Holborn and St. Martin's-in-the-Fields). Under these circumstances a study of the construction of furnaces, and the more or less complete combustion of coal, was forced upon us, so that our evidence might be of value when attempting to apply the stronger provisions of the Act, which required furnaces to be constructed so as to consume or burn the smoke arising from such furnace, the colour of the smoke being immaterial and the penalties cumulative. We then found that during the latter part of the eighteenth and the first half of

the nineteenth centuries, engineers of eminence had introduced and patented many and diverse appliances attempting to solve the problem of full oxidisation of furnace fuel. For example, patents were granted for:

"Admitting air through openings or over the furnace door," to James Watt, 1785; Robertson, 1800; and Billingsley, 1842.

"Gradually coking the coal," James Watt, 1785; Robertson, 1800; Drew, 1837; Jukes, 1838; and Blackwell, 1848.

"Letting air in at the bridge or by hollow furnace bars," W. Thompson, 1796: Mons. de Promy, 1810; Wm. Sheffield, Wakefield, and Johnson, all three in 1812; Parkes, 1820; Chapman, 1824; Coad, 1835; S. Hall, 1836; C. W. Williams, 1839; Kurby, 1840; Prosser, 1842; Butler, 1845; Whiteley, 1845; Robertson, 1848; Johnson, 1849; and in 1854, Woodcock, Parkes, and Galloway.

"Rocking Bars," Oldham, 1825; Miller, 1839; Newcome, 1849; Hall, 1849; Galloway, 1849; Hargreaves, 1850.

"Mechanical Stokers, supplying coal through hoppers," Robertson, 1800; Brunton and Gregson, both 1816; Chapman and Stanleys, both 1824; Whitless, 1845; Acocks, 1848; Sherba, 1852.

"Side firing, alternately," Tosh, 1815; Rodda, 1838; T. Hall, 1837; Green, 1853.

"To automatically and gradually close furnace doors," Pritchard, 1820; Prideaux, 1850.

"Injection of jets of steam," Chappe, 1836; Trison and Bull, 1838.

"A second fire to burn smoke formed," Collier in 1843.

"Upward firing," Godwin and Foard in 1841.

"Inclined bars," Baron von Rather, 1840; and Hendruch, 1841.

"Washing smoke to deposit the carbon," C. W. Ward, 1792; Jeffries, 1824; Hedleys, 1834.

Obviously a longer period of study was necessary than could be reasonably expected of sanitary inspectors, who had much to do besides looking after smoke. In the witness box, under cross examination, the weakness of our knowledge of a special method of combustion was frequently shown up, in strong contradiction to the *expert* who was *certain* that the smoke the inspector had seen could not be sent forth from the furnace *he* had constructed, as the admission of air was perfect; or that the mechanical stokers could not supply the coal so badly. One or the other mechanism was absolutely infallible, and he (the expert) was also certain that the particular furnace *was* constructed so as to burn, *as far as possible*, all the smoke arising from such furnace. Under such circumstances is it to be wondered that the magistrates are loth to inflict the

cumulative penalty? Is it not most probable, that, after duly discounting the expert's evidence, he who has spent the whole of his life in the study and prevention of smoke nuisances knows more about the "*as far as practicable*" than the sanitary inspector does? Thus, rarely is a fine of more than £10 obtained for any one offence, and then, if obtained, only after adjournments to again take observations. During this period great care is exercised and no smoke sent forth. Under these circumstances the very usual practice now is to proceed under the easier clause which makes it an offence to send forth black smoke, from certain chimneys, in such quantity as to be a nuisance, as no evidence of construction of furnaces or to as far as possible consume the smoke is admissible here.

So the sanitary inspector has to deal with a nuisance either from his own observation as a statutory officer, or as the result of his observation upon the complaint of some other person. His power is here confined to black smoke; on the emission of grey, blue, brown, yellow, or white smoke, in whatever quantity, he has nothing to report.

Then, what is the quantity of black smoke emitted which constitutes such a nuisance? Surely the quantity emitted must depend upon two factors: the density of the black smoke, and the length of the emissions. Obviously an emission of smoke, black and as dense as it is possible to conceive, for a period of, say one minute, can be equalled in quantity by a black smoke, which appears against the clear sky to be grey, if the latter be continuously emitted for, say half an hour.

A conviction is naturally most easily obtained when the inspector swears that the smoke on the occasion referred to was *dense black* smoke, and under such circumstances short emissions of three minutes are much more useful in obtaining convictions than a less dense smoke for a much longer period.

On the other hand those who have studied this question, or who have carefully followed the course of this Conference, cannot fail to note that the aim is very largely to abate the ill-effects of the discharge of the many slighter emissions, which in the aggregate are so enormous, and affect our climate so greatly. For example, this side is enforced by the Coal Smoke Abatement Society, and affects sanitary inspectors in two ways.

Firstly it is used as a defence by smoke producers, in large chimneys, when those chimneys appertain to furnaces used to heat buildings and cook the food consumed therein. In such cases they try to prove that notwithstanding the fact that some smoke is emitted from their chimney, yet it is much less than the aggregate amount would be when sent forth

from the number of chimneys necessary if each flat therein had its own kitchen and other chimneys. Then again, strong representations of the emission of black smoke for long periods, which is certainly not dense, are forwarded to the local authority to deal with.

But whilst the definition of what is a nuisance as to black smoke is left with an inspector, shall he refuse to use his own judgment and accept that of the smoke producer? It would be as unwise to do the latter as to accept the judgment of the most earnest exponent of smoke abatement here, who, in reaching after his ideal, aims so high that there is a danger of unconscious bias, and a tendency to re-enact the law under which one John —— was, in 1306, tried, condemned and executed for burning coal in the City of London.

SMOKE NUISANCE INSPECTORS AND THEIR DIFFICULTIES.

By WM. NICHOLSON.

Smoke Inspector, Sheffield.

THE smoke nuisance and its abatement is one of the most important of public health questions.

It is a national nuisance. The pollution of the atmosphere which affects everybody does incalculable harm to public health and property and all classes ought to assist in its abatement.

To satisfactorily solve the question it is absolutely necessary to proceed in practical lines to prevent injury to trade.

Smoke.—All smoke is a nuisance when in contact with persons or property, for it produces dirt and damage.

Necessary Nuisance.—The smoke which it is impracticable to prevent in boiler, furnace, and fireplace is a necessary nuisance.

Statutory Nuisance.—Smoke which can be practically prevented is a statutory nuisance. Experts differ as to the number of minutes in a given period which constitute a nuisance. Some authorities say two minutes of black smoke from a furnace in one hour is a statutory nuisance others three, four, five, six, and as much as fifteen.

Board of Experts.—To ascertain what is and what is not a statutory nuisance it is imperative to have a *Board of Experts.* They would test smoke preventing appliances and processes suitable for boilers, furnaces and fireplaces, and find out what smoke was necessary under various conditions of working.

The necessary smoke would be the uniform standard allowed, and above the said amount would be a nuisance within the meaning of all good smoke law. The standards arrived at would be adopted by local authorities, and remain in force until it was found practicable to reduce them.

The work of such a suggested Board would be of great value to public health, manufacturers, and owners of appliances.

Cost.—In 1902 the German Government granted £4,000, the money

to be used in giving courses of instruction and practical lessons to firemen and engineers, with the object of procuring smoke abatement.

If Governments will not provide money for this necessary work to be done, then manufacturers and owners of appliances ought to.

[*This Discussion applies to the subject before the Conference on Friday morning—"Administration, Legislation, and Necessary Reforms."*]

Mr. Arthur J. Martin (London) said that, from the Report presented that morning by the Secretary to the Coal Smoke Abatement Society, it would seem that the absence of progress at the present time was due, not so much to lack of the necessary powers as to the neglect of local authorities to exercise the powers which they already possessed. Dr. Butler had given them on the previous day a striking example of what could be accomplished under the existing law, if the local authority chose to enforce it. However, whether they wished it or not, legislation was bound to take place. It might not take the form of measures introduced by the Government, or by associations like the Coal Smoke Abatement Society; but they would get it by a sidewind in the shape of clauses to bills promoted by companies or municipal corporations. These clauses might, on the one hand, invest the promoters with powers or monopolies which it was not to the public interest to confer upon them, or, on the other, might impose restrictions put forward by opposing parties with the express object of hampering the enterprise and reducing its utility to the public. Such clauses were apt to crystallise into precedents. In dealing with such highly technical matters Parliament ought not to have to depend for guidance to such an extent as it now did upon the interested statements of the promoters and their opponents. The industries of the country were becoming more and more dependent upon applied science; and it was high time that the Government should have at its back an expert scientific body to watch the interests of the country as affected by proposed legislation bearing on technical matters.

Mr. Fred Cleeves (London) said that before the British public would submit to any law, it must be convinced that that law was just, fair, and reasonable. As the officials of these societies told them, there was enough passive resistance to the laws already on our Statute Book. Of course, a man had no more right to poison another man with coal smoke than he had with arsenic fumes, but up to the present the public have accepted the first as inevitable. Some people actually believed that it was beneficial. Our first and most pressing duty, therefore, was to educate the public; then any necessary legislation will follow as a matter of course. They had heard of the smoke prevention laws in New York and Berlin. He had been in New York, and in his opinion, if it were not for those laws, New York would be uninhabitable. They

burn solely anthracite coal in New York. He also knew Berlin pretty well. In his opinion it was the cleanest capital in Europe. Some years ago, the police of Potsdam told the proprietor of a factory there, one that had existed for many generations, that he must stop making smoke. The proprietor pleaded the excuse that they were so familiar with here, that he had tried every means to abate the smoke, etc. "No, you haven't," said the police, "you should use anthracite coal, then you cannot make smoke." They gave him a month wherein to change his fuel or stop his works. He repeated his belief that education must precede legislation, and was sure that when the British manufacturers and householders were convinced that they could save money by not making smoke, they would cease to make it.

Councillor W. Muirhead, J.P. (Liverpool) said that he wished to controvert the statement made by Baillie Anderson (of Glasgow) that Glasgow was the first municipality to move in the matter of smoke abatement. Liverpool was very many years ahead of the rest of the country, even of the Scotch Acts of 1857, because Liverpool moved in this matter in 1854. It was very necessary the word *black* should be omitted, and the wording of the Liverpool Act should be substituted; that such cases as came under the ken of the smoke inspectors and sanitary staff were as a rule tried by the *Stipendiary*, an example that all large municipalities might follow; and he would suggest the framing of a universal Act for Great Britain and Ireland, on the lines of the Liverpool Local Act.

Dr. Ormandy (Warrington) expressed the hope that the Congress would not terminate without some practical step being taken. On that day a plea had been raised by several speakers for the consolidation of the laws relating to smoke emission. The speaker thought that an almost more important step at the present moment was the consolidation of the smoke abatement societies of the country. It had been stated that the London Society were so hampered for want of funds that little could be done. He thought that this was largely owing to ignorance among the public as to the value of the work that was being done. He proposed that the London Society should be the head of a British Smoke Abatement Society and an arrangement might be made that all the provincial societies paid an affiliation fee to the central society, much on the lines upon which the Automobile Club of Great Britain and Ireland is run at the present time. With such a central society it would be possible to lay before the Government measures which had a wide-spread and powerful support. It was only through such a central society that the investigations proposed in Sir John Primrose's paper could be carried out. Many speakers had referred to the splendid work carried out by the inspectors under the Alkali Act. He thought that one duty of such a central society would be to ask Government to widen the scope of the Alkali Act so as to include the smoke nuisance,

thereby removing the present anomalous condition of affairs existing whereby men appointed by local authorities are placed in the position of smoke inspectors with absolutely no security of tenure. Manufacturers would act upon the report of properly trained and fully authorised Government inspectors, but refuse to do so under the present circumstances, and the law itself was rendered practically valueless by the fact that the inspectors as appointed at present were afraid of acting.

DR. SIDNEY DAVIES (Woolwich) referred to the fact that proceedings in London for smoke nuisance were usually taken under Sec. 24 of the Public Health (London) Act, 1891, under which it was necessary to serve notice before taking out a summons. In Woolwich, however, it had been found that the best way was to proceed under Sec. 23, (2), (b), which made it penal to negligently use any furnace so that the smoke was not effectually consumed. When the sanitary inspector observed any smoke nuisances, he at once entered the works and took note as to the mode of stoking, and the nature of the fuel, and was then able to give evidence that there had been some neglect in one of these respects. Previous speakers had stated that domestic smoke had the greater share in obscuring London air, and had quoted the large amount emitted on Sunday when the Sunday dinners were being cooked. Dr. Davies considered that this might be true for the West End, but it certainly was not the case in the East End of London. From mid-day Saturday to Monday morning the Houses of Parliament could usually be seen from Shooters' Hill, when it was daylight, but rarely were they visible during the rest of the week. This showed that in the East, at any rate, factories were the chief source of London smoke. There were some factories, however, which were exempted from the Public Health Acts. The Arsenal was the principal source of smoke nuisance in Woolwich, and no redress could be obtained. No doubt the Arsenal officials honestly believed they were doing their best to diminish smoke, and had appointed inspectors to watch the chimneys, but the extraordinary thing was that the inspectors could not see the smoke. Dr. Davies endorsed what Mr. Chubb had said with respect to the Arsenal, and hoped that it would go out from that Conference, and reach the ears of His Majesty's newly appointed Government, that the Government factories were the creators of perhaps the greatest smoke nuisance in the whole of London, and consequently guilty of wasting a large amount of public money.

THE PRESIDENT.

HIS GRACE THE DUKE OF ARGYLL, K.G., K.T., G.C.M.G., G.C.V.O., LL.D., D.Sc., D.L.

1912.

Official Catalogue

Of the

International

Smoke Abatement Exhibition

Under the direct Auspices of the Coal Smoke Abatement Society,

Royal Agricultural Hall, London, N.,

SATURDAY, MARCH 23rd,
to
THURSDAY, APRIL 4th,
Inclusive.

F. W. BRIDGES, Organizing Manager.
LAWRENCE W. CHUBB, F.C.I.S., Secretary.
(Secretary of Coal Smoke Abatement Society).

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THE
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The Coal Smoke Abatement Society was formed in 1898, to further the aims of those who desire a cleaner atmosphere.

Its objects are:—

(*a*) To aid in enforcing, through the Local Sanitary Authorities, the existing law dealing with smoke nuisance, which is contained in the *Public Health* (*London*) *Act*, *1891*, and the *Public Health Act*, *1875*. For this purpose it employs Inspectors, who continually make observations of smoke nuisances, which are reported to the proper authorities. ~~The number of such reports sent in exceeds 16,000.~~

(*b*) To promote and encourage all voluntary efforts to abolish smoke from dwelling houses, and to enquire into the best means of effecting this object.

(*c*) To obtain particulars and evidence of the methods of dealing with smoke nuisances at home and abroad.

(*d*) To publish information on matters relating to smoke nuisances and the methods by which they may be abated, and for that purpose to encourage the organisation of Exhibitions and stimulate invention by the offer of prizes and to conduct tests of heating and cooking apparatus, as well as of appliances for the reduction of smoke from factories.

(*e*) To bring about the amendment of the present law where it is not efficient.

The minimum Annual Subscription is 5s. Larger Subscriptions and Donations of any amount are earnestly solicited. Contributions of £5 5s. 0d. constitute Life Membership.

Introduction.

THIS Exhibition owes its inception to a desire freely expressed by manufacturers to the Coal Smoke Abatement Society that steps should be taken to arrange in the Metropolis a display of apparatus and fuels suitable for industrial and domestic use, and designed to abolish or diminish the Coal Smoke nuisance.

Smoke Abatement in other Days.

Smoke Abatement has long formed a subject for discussion in this country. It possesses, indeed, some claim to historic interest.

As far back as the year 1228, a thoroughfare in the City of London was known as "Sacoles Lane," and to this day has little changed its original designation since it is still called "Seacole Lane."

The earliest known incident illustrating the need for Smoke Abatement is to be found in the record that in the year 1257, Eleanor, Queen of Henry III, was constrained to leave Nottingham for Tulbury Castle in order to escape the smoke of the "Sea Coles."

In the year 1273, the use of coal was prohibited in London as being prejudicial to public health. The destruction of forests, however, resulted in the rapid substitution of coal for wood and charcoal, and the nuisance arose which ever since has laid London and all other large cities under its spell of dirt and darkness.

Unwilling to accept the new condition of affairs, the "nobles, prelates and others," going to London to attend Parliament, took the lead in organising the first Smoke Abatement campaign."

Their agitation led, in 1306, to the issue of a Royal Proclamation prohibiting artificers from using coal in their furnaces. This step, proving ineffectual, was followed in 1307, by the appointment of a Commission of Oyer and Terminer, which was instructed "to inquire of all such who burnt sea cole in the City, or parts adjoining, and to punish them for the first offence with great fines and ransoms, and upon the second offence to demolish their furnaces."

If, therefore, a solution of the smoke problem, even in its early stages, could have been found in coercive action tantamount to prohibition, the nuisance would have been nipped in the bud.

But the value of the newly discovered fuel was too great for repressive measures to do more than retard the development of the coal mining industry. There followed, it is true, occasional outbursts of indignation, such as those of John Evelyn in his "Fumifugium" against the polluting effect of coal smoke. Notwithstanding such protests, the nuisance gradually and naturally grew until the invention of the steam engine gave an enormous impetus to the production and utilisation of coal and immediately aggravated the evil.

The attention of Parliament was soon directed to the subject, and in 1819, a Committee was appointed to enquire how far it was practicable "to compel persons using steam engines and furnaces in their different works, to erect them in a manner less prejudicial to public health and public comfort." In their report, the Committee

expressed a confident hope that "the nuisance so universally, and so justly complained of, may at least be considerably diminished if not altogether removed." The same Committee in a subsequent report went much further, being evidently convinced that smoke-preventing appliances existed which could and should be used.

Other Parliamentary enquiries resulted in similar reports and in legislation designed to minimise, if not to abolish the smoke nuisance.

The Modern Campaign.

It was not, however, until about thirty years ago that any intelligent effort was made to systematically study the problem. A Smoke Abatement Committee of the National Health and Kyrle Societies was appointed, and an Exhibition was held at South Kensington in 1881. This aroused much interest, but no further practical steps were taken until Sir William Richmond and his friends, in 1899, formed the Coal Smoke Abatement Society.

Other smaller Smoke Abatement Exhibitions followed, notably displays at the Royal Horticultural Hall in 1905, at Sheffield in 1909, at Glasgow in 1910, and at Manchester in 1911. Scores of meetings have been held in all parts of the country. Local authorities have been encouraged to regard the protection from pollution of the air we breathe, as a sanitary matter. In short, from the time the Coal Smoke Abatement Society was founded, there has been no looking backward. Public opinion has been definitely awakened. Gas Companies and Electricity Supply Undertakings vie with each other in bringing before the notice of the community, the special advantages which their systems of cooking and heating offer to the householder. Natural and artificial smokeless fuels are being constantly pressed upon the public. Heating Engineers have brought their special knowledge to bear upon the design of open grates, and of Hot Water Heating Systems, and it is not now possible for any one to say that he cannot personally contribute to the great work of cleansing the atmosphere.

In the realm of industry, too, striking improvements have been wrought, and it is at last generally recognised that scientific principles can now be so applied to the production of power that, in most cases at all events, it is in a pecuniary sense advantageous to avoid the emission of unreasonable volumes of smoke.

The result of the modern crusade is already apparent in a decrease of the smoke-laden fogs, which a generation ago made existence in the Metropolis a burden for several months in each year. It is shown in a steady and welcome gain in the amount of Winter sunshine. It is also shown in the concensus of medical and scientific opinion as to the baneful effect exerted by smoke and the other products of inefficient combustion on human and animal life, vegetation and property of all kinds. It is manifested, too, in the remarkable reduction which has taken place in factory and domestic smoke; and at last the goal for which Smoke Abatement enthusiasts have been striving—a clean and pure air—is within reasonable distance.

The International Smoke Abatement Exhibition.

The International Smoke Abatement Exhibition is designed to carry still further the work of education. By means of the Conferences to be held in connection with the Exhibition, and to which so many important Municipalities will send delegates, both from at home and abroad, it is hoped some scheme of concerted action may be evolved.

It is, too, the earnest desire of the Society and of the Exhibition Council, that the opportunity afforded by this display of the most modern methods of combatting the smoke nuisance will result in the adoption by manufacturers of the many improvements shown to be available for industrial purposes. The Council further trust that the co-operation which they have received from the manufacturers or purveyors of grates,

fuels, gas, and electricity will lead to the universal adoption of smokeless methods of cooking and heating. The Exhibition has necessitated much labour and expense to the Exhibitors at a particularly trying time in the country's economic history, and the Organising Manager and Council will be glad to feel that it has also given an impetus to trade and to that industrial energy and scientific ingenuity without which further progress is impossible.

The Coal Strike, the effects of which are now being so widely felt and deplored and which unfortunately has synchronised with the Exhibition has nevertheless diverted renewed attention to the pressing need for conserving our National Coal Supplies. When Smoke Abatement has been brought about, not the least of its beneficial results will be the termination of the wanton waste which has hitherto ordinarily attended the burning of the fuel whether for power or domestic purposes.

The Exhibition, at all events will prove to the satisfaction of any unbiassed observer that, without financial sacrifice, it is now not only possible, but even advantageous to the manufacturer and householder alike to share directly in the vitally important work of the cleansing of the atmosphere.

LAWRENCE W. CHUBB,
Secretary,
Coal Smoke Abatement Society,
25, Victoria Street, Westminster,
S.W.

March 18*th*, 1912.

The International

Smoke Abatement Exhibition

Under the direct Auspices of the Coal Smoke Abatement Society.

1912 ROYAL AGRICULTURAL HALL, LONDON. 1912

March 23rd to April 4th (inclusive).

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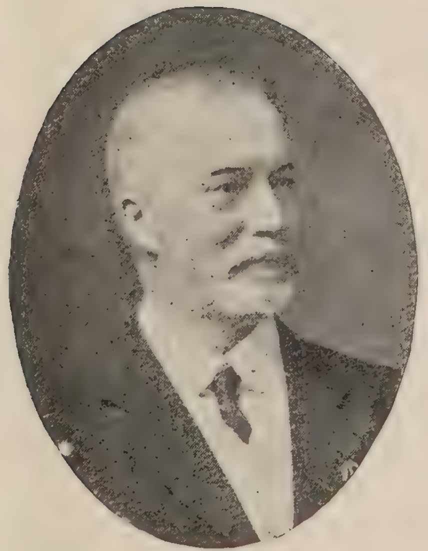

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HENRY ADAMS, M.I.C.E., F.S.I.
FRANK BAILEY, M.I.C.E.
SYDNEY W. BAYNES, M.I.C.E.
A. E. BROADBERRY.
W. D. CARÖE, F.R.I.B.A.
G. W. CHILVERS, M.R.S.I., F.R.M.S.
CHARLES CLARE.
WILLIAM BALFOUR CLARKE.
H. CHATFIELD CLARKE, F.S.I.
HERMAN CLARKE.
R. CLAYTON.
FREDERICK CLEEVES.
F. S. COURTNEY, M.I.C.E., M.I.M.E.
CYRIL DAVIS.
H. A. DES VOEUX, M.D.
SYDNEY T. DOBSON.
D. N. DUNLOP, A.I.E.E.
A. P. FLORENCE, M.I.H.V.E.
W. FRETWELL.
T. GLOVER.
F. W. GOODENOUGH.
GEORGE A. GOODWIN, M.I.C.E., WH.TH.Schlr.
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J. W. HELPS.
J. JOWETT.
J. B. S. KERSHAW.
Prof. VIVIAN LEWES, F.I.C., F.C.S.
A. P. MAIN.
A. J. MARTIN, M.I.C.E., F.G.S.
F. McLEOD.
ERNEST NEWTON.
HENRY O'BRIEN.
JOHN S. OWENS, M.D., A.M.I.C.E.
O. J. PARKER.
ALEXANDER RITCHIE, J.P.
A. ROSS, M.I.C.E.
W. D. SCOTT-MONCRIEFF.
A. HUGH SEABROOK.
F. E. SHEARER.
S. Y. SHOUBRIDGE.
ALBERT SLATER.
A. K. STEVEN.
HANBURY THOMAS.
H. M. THORNTON.
THACKERAY TURNER, F.S.A., F.R.I.B.A.
F. J. WALKER.
D. MILNE WATSON.
H. JAMES YATES.

SECTIONAL SUB-COMMITTEES.

(a.) Electricity.

R. S. ERSKINE (Chairman).
S. T. DOBSON.
F. J. WALKER.
S. W. BAYNES.
F. BAILEY.
A. HUGH SEABROOK.
D. N. DUNLOP.

(b.) Hot Water, Air and Steam Heating.

O. M. ROW (Chairman).
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W. D. CAROE.
H. ADAMS.
G. A. GOODWIN.
F. S. COURTNEY.
A. RITCHIE.
W. FRETWELL.

(c.) Gas, Lighting and Heating.

R. G. SHADBOLT (Chairman).
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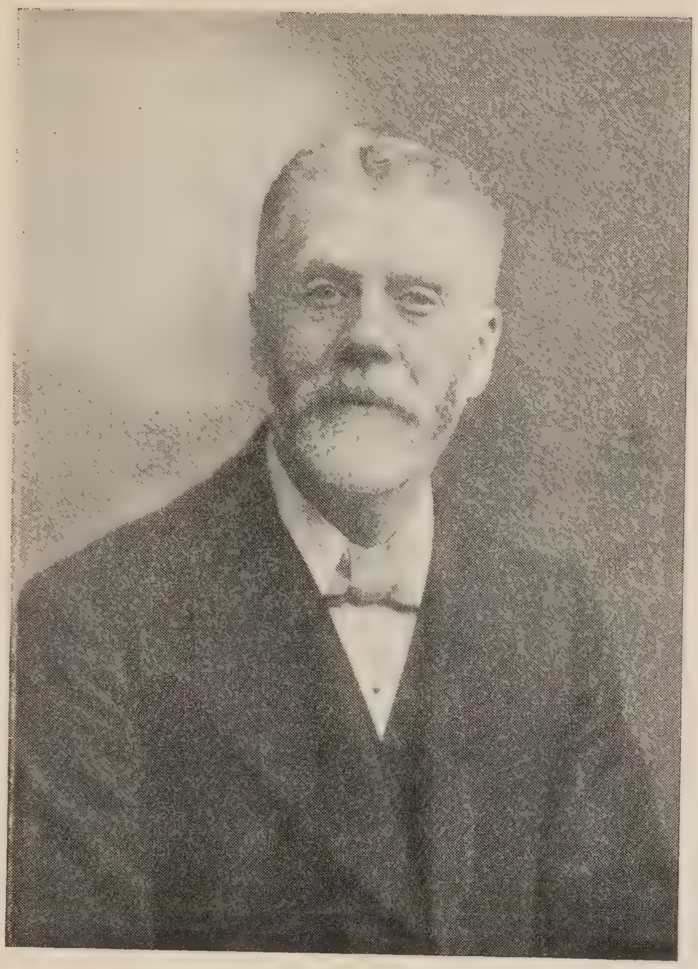
F. W. GOODENOUGH.
D. MILNE WATSON.
J. W. HELPS.
F. McLEOD.
S. Y. SHOUBRIDGE.
A. P. MAIN.
A. J. MARTIN.
HANBURY THOMAS.
H. JAMES YATES.
CYRIL DAVIS.
T. GLOVER.
R. CLAYTON.
CHAS. CLARE.
H. M. THORNTON.
Prof. VIVIAN LEWES.

(d.) Grates and Smokeless Fuels.

H. B. SEARLES-WOOD (Chairman).
A. P. FLORENCE.
F. CLEEVES.
H. O'BRIEN.
D. MILNE WATSON.
A. RITCHIE.
H. THACKERAY TURNER.
E. T. HALL.
H. CLARKE.
J. JOWETT.
S. W. BAYN
ERNEST NEWTON.
A. K. STEV

LOAN COMMITTEE.

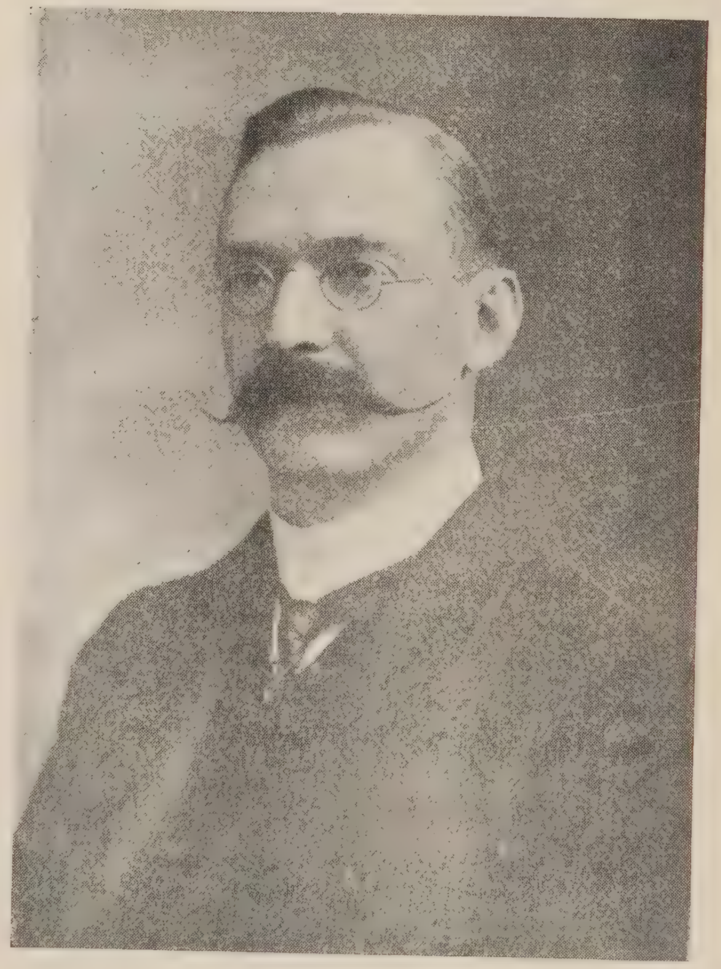
H. A. DESVOEUX, M.D. (Chairman).
Commander W. F. CABORNE, C.B., R.N.R.
Dr. H. N. DICKSON.
A. F. LINDEMANN, F.
LEWIS R. S. TOMALIN



Organizing Manager:

FREDERIC W. BRIDGES,

Organizer of
The Engineering and Machinery Exhibition, Olympia, London, 1910; The Printing Exhibition, Agricultural Hall, 1910; The Chemical Engineering and Industries Exhibition, Agricultural Hall, 1911, etc., etc.



Secretary:

LAWRENCE W. CHUBB, F.C.I.S.

(Secretary of Coal Smoke Abatement Society).

THE MANAGEMENT OF THE EXHIBITION.

Committees—contd.

INDUSTRIAL AND MOTIVE POWER PLANTS; BOILERS AND ACCESSORIES COMMITTEE.

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F. S. COURTNEY, M.I.C.E., M.I.M.E. (Vice-Chairman).
D. MILNE WATSON (Vice-Chairman).
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JAMES BIRD.
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H. SHOOSMITH, M.I.C.E.
S. Y. SHOUBRIDGE.
A. STOKES.
F. J. WALKER.
W. WINGATE.
J. S. OWENS, M.D., A.M.I.C.E. (Hon Secretary).

SECTIONAL SUB-COMMITTEES.

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(b.) Gas.

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S. RIDEAL.
A. STOKES.
CHAS. CLARE.
Prof. VIVIAN LEWES.

(c.) Electrical Appliances

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C. W. HILL.
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D. N. DUNLOP.

(d.) Testing Appliances.

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C. W. HILL.
G. A. GOODWIN.
Dr. S. RIDEAL.
R. LESSING.
Prof. H. ADAMS.
J. P. MAGINNIS (Hon Sec.).

VENTILATING AND DUST PREVENTION COMMITTEE.

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J. P. MAGINNIS, A.M.I.C.E., M.I.M.E. (Vice-Chairman).
HENRY CARTER.
H. CHATFIELD CLARKE.
H. A. DES VOEUX, M.D.
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THOS. W. HOW, F.R.G.S., F.C.I.S.
E. L. JOSEPH.
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SIR THOS. OLIVER, M.D., LL.D., D.Sc.
J. S. OWENS, M.D., A.M.I.C.E.
MICHAEL PAL.
Captain H. RIALL SANKEY, R.E. (ret.) M.I.C.E. M.I.M.E.
DR. W. N. SHAW, M.A., D.Sc., LL.D., F.R.S.
LEWIS R. S. TOMALIN.
S. RIDEAL, D.Sc., F.I.C. (Hon. Secretary).

Notice to Visitors.

The Exhibition will be opened from March 23rd to April 4th inclusive from 10 a.m. to 10 p.m. every day.

The Orchestra will perform daily from 3 to 5 and 7 to 9.45 p.m.

The Manager's Offices are situated near the Barford Street Entrance.

There is a Postal and Telegraph Office in the Building.

Refreshments are provided at the Bars on either side of the Hall.

Luncheons, Teas, etc., in the Dining Hall, North side.

The Gas Light and Coke Company in their Hall, near the Clock in main Building, supply Teas Free to Gas Consumers and Residents in the Company's area.

Electrically Cooked Luncheons, Teas, &c., in the Electric Restaurant, Electricity Hall—near the Entrance. Music by the Russian Balalaika Orchestra at intervals daily.

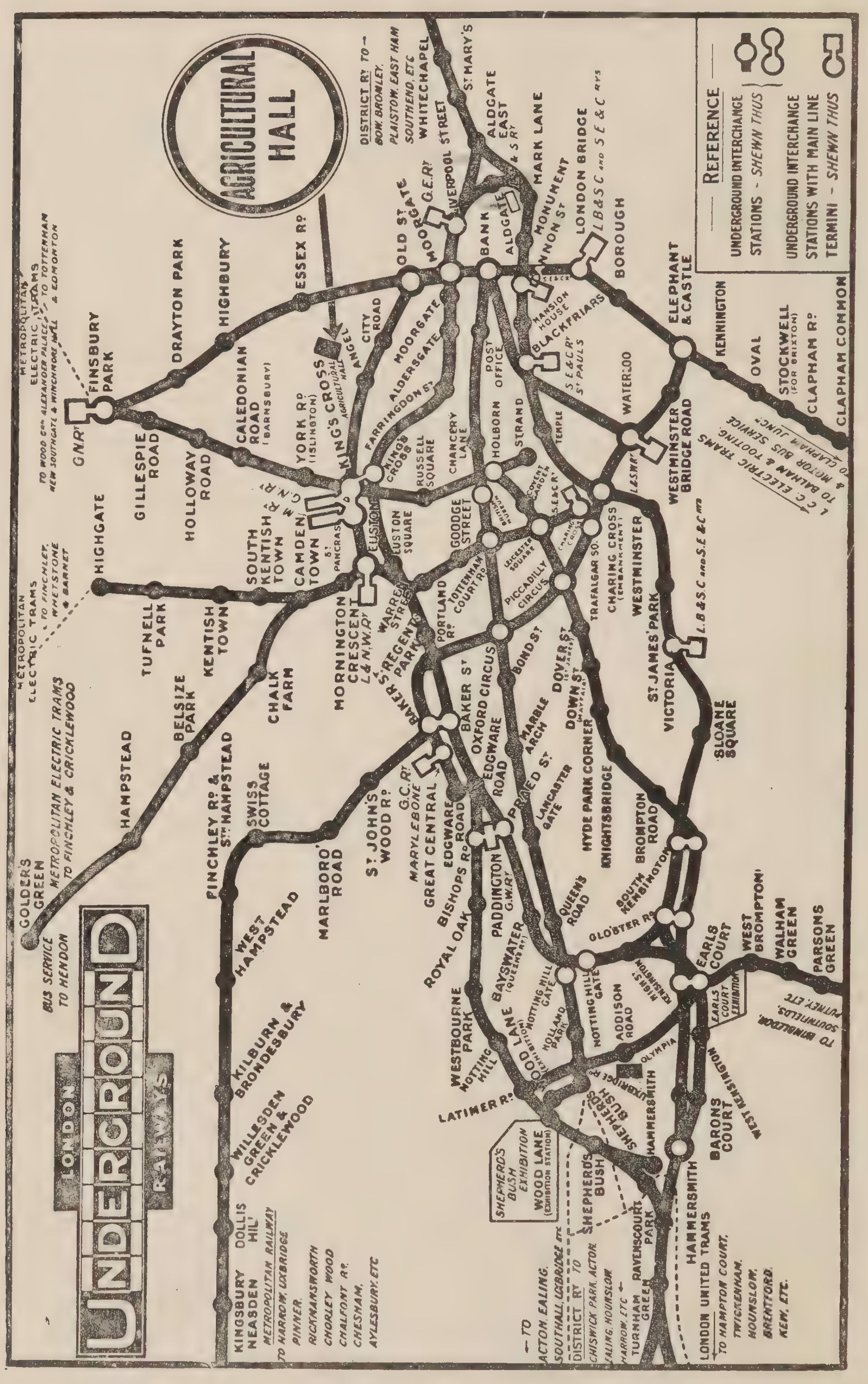
Lavatories for Ladies and Gentlemen are provided on each side of the Hall.

No person other than an Exhibitor or an Exhibitor's Representative is allowed to canvass Visitors or Exhibitors for orders, or for any purpose whatever, or to take sketches from the Exhibits. Any transgression of these rules renders such person or persons liable to immediate expulsion from the building.

The Exhibition is connected with all the principal Railways and Trams.

It must be understood that all persons visiting the Exhibition do so under the regulations of the Management, and also that the Management are not to be held responsible for any accident which may happen to any person at the Exhibition.

In any case of complaint please address the Organising Manager (in confidence) at the Office in the Exhibition, or at 124, Holborn, E.C.



LONDON
UNDERGROUND
RAILWAYS
AGRICULTURAL HALL
REFERENCE
UNDERGROUND INTERCHANGE STATIONS - SHEWN THUS
UNDERGROUND INTERCHANGE STATIONS WITH MAIN LINE TERMINI - SHEWN THUS
GOLDERS GREEN
BUS SERVICE TO HENDON
METROPOLITAN ELECTRIC TRAMS TO FINCHLEY & CRICKLEWOOD
HAMPSTEAD
BELSIZE PARK
CHALK FARM
HIGHGATE
TUFNELL PARK
KENTISH TOWN
SOUTH KENTISH TOWN
CAMDEN TOWN
MORNINGTON CRESCENT
FINSBURY PARK
DRAYTON PARK
HIGHBURY
ESSEX RD
GILLESPIE ROAD
HOLLOWAY ROAD
CALEDONIAN ROAD
YORK RD
KING'S CROSS
ANGEL
CITY ROAD
OLD ST
MOORGATE
LIVERPOOL STREET
ALDGATE
ALDGATE EAST
MARK LANE
MONUMENT
LONDON BRIDGE
BOROUGH
ELEPHANT & CASTLE
KENNINGTON
OVAL
STOCKWELL
CLAPHAM RD
CLAPHAM COMMON
BANK
BLACKFRIARS
MANSION HOUSE
ALDERSGATE
FARRINGDON ST
EUSTON
EUSTON SQUARE
ST PANCRAS
RUSSELL SQUARE
CHANCERY LANE
HOLBORN
POST OFFICE
STRAND
TEMPLE
WATERLOO
WESTMINSTER BRIDGE ROAD
CHARING CROSS
TRAFALGAR SQ.
WESTMINSTER
ST. JAMES' PARK
VICTORIA
SLOANE SQUARE
GOODGE STREET
TOTTENHAM COURT RD
PICCADILLY CIRCUS
LEICESTER SQUARE
OXFORD CIRCUS
BOND ST
DOVER ST
DOWN ST
PORTLAND RD
REGENT'S PARK
BAKER ST
MARBLE ARCH
HYDE PARK CORNER
KNIGHTSBRIDGE
BROMPTON ROAD
SOUTH KENSINGTON
GLO'STER RD
EARLS COURT
WEST BROMPTON
WALHAM GREEN
PARSONS GREEN
EDGWARE ROAD
PRAED ST
LANCASTER GATE
MARYLEBONE
GREAT CENTRAL
BISHOPS RD
PADDINGTON
QUEEN'S ROAD
BAYSWATER
NOTTING HILL GATE
HOLLAND PARK
ADDISON ROAD
HIGH ST KENSINGTON
OLYMPIA
SHEPHERDS BUSH
WOOD LANE
ROYAL OAK
WESTBOURNE PARK
NOTTING HILL
LATIMER RD
UXBRIDGE RD
HAMMERSMITH
BARONS COURT
WEST KENSINGTON
RAVENSCOURT PARK
TURNHAM GREEN
SWISS COTTAGE
FINCHLEY RD & ST. JOHNS HAMPSTEAD
ST. JOHN'S WOOD RD
MARLBORO' ROAD
WEST HAMPSTEAD
KILBURN & BRONDESBURY
WILLESDEN GREEN & CRICKLEWOOD
DOLLIS HILL
KINGSBURY NEASDEN
METROPOLITAN RAILWAY
LONDON UNITED TRAMS

INTERNATIONAL

Smoke Abatement Exhibition.

Under the direct Auspices of the Coal Smoke Abatement Society,

Programme of

CONFERENCES and LECTURES.

SECTION A.—March 26th, 1912, at 11 a.m. and 2.30 p.m.

Chairmen: 11 a.m., Sir William Ramsay, K.C.B., F.R.S. (President British Association); 2.30 p.m., W. Whitaker, Esq., B.A., F.R.S.

SMOKE POLLUTION.—1. Its economical and artistic aspects.

2. Effects on animal and plant life.

SECTION B.—March 27th, 1912, at 11 a.m. and 2.30 p.m.

Chairmen: 11 a.m., Sir William B. Richmond, K.C.B., R.A. (President, Coal Smoke Abatement Society); 2.30 p.m., Captain H. Riall Sankey, R.E. (ret.), M.I.C.E., M.I.M.E.

SMOKE ABATEMENT.—1. Work done and to be done in organizing preventive action.

2. The Physics of Smoke Abatement Apparatus and practical expedients for the abolition of smoke both industrial and domestic.

SECTION C.—March 28th, 1912, at 11 a.m. and 5 p.m.

Chairmen: 11 a.m., Julian S. Corbett, Esq., LL.M., F.S.A. (Chairman, Conference Committee); 5 p.m., Lord Justice Fletcher Moulton.

LAW AND LEGISLATION.—1. Proposed new legislation.

2. The existing law and its adminstration both at home and abroad. Proposed Royal Commission.

CONFERENCE COMMITTEE.

JULIAN S. CORBETT, LL.M., F.S.A. (Chairman).
FRANK BAILEY, M.I.C.E.
FREDERICK CLEEVES.
SYDNEY T. DOBSON.
H. A. DES VOEUX, M.D.
EDWIN T. HALL, F.R.I.B.A.
CLAUDE W. HILL, A.M.I.C.E., M.I.E.E.

W. WHITAKER, B.A., F.R.S. (Vice-Chairman).
A. F. LINDEMANN, F.R.A.S.
J. P. MAGINNIS, A.M.I.C.E., M.I.M.E.
JOHN S. OWENS, M.D., A.M.I.C.E.
ALEXANDER RITCHIE, J.P.
E. D. SIMON.
F. J. WALKER.

R. LESSING, Ph.D., F.C.S. (Hon. Secretary).

Lawrence W. Chubb, Secretary,
Coal Smoke Abatement Society,
25, Victoria Street,
Westminster, S.W.

PROGRAMME.

Tuesday, March, 26th, 1912.

Section A. Smoke Pollution.

11 a.m.

Its Economical and Artistic Effects.

CHAIRMAN—
SIR WILLIAM RAMSAY, K.C.B., F.R.S.

1. SIR ARTHUR CHURCH, K.C.V.O., D.Sc., F.R.S., F.S.A.
"The action of Coal Smoke on Building Stones and Mural Paintings.

2. MR. NOEL HEATON, B. Sc., F.C.S.
"The Influence of Smoke on Decorations."

3. MR. HARRY REDFERN (Representing the Society for the Protection of Ancient Buildings).
"The effect of Coal Smoke on Buildings.

4. DR. S. RIDEAL, D.Sc., F.I C.
"Effects on town air on Metal Work."

5. The HON. ROLLO RUSSELL, M.A., F.R., Met. Soc.
"Smoke and Fog."

2.30 p.m.

Effects on Animal and Plant Life.

CHAIRMAN—
MR. W. WHITAKER, B.A., F.R.S.
(Vice-Chairman, Conference Committee.)

6. MR. R. G. K. LEMPFERT, M.A., (Superintendent Forecast Division of the Meteorological Office).
"Sunshine Records."

7. MR. J. W. BEAN (Assistant Curator of the Royal Botanic Gardens, Kew).
"A note on recent observations of the Smoke Nuisance at Kew Gardens."

8. MISS AGAR (Landscape Gardener to the Metropolitan Public Gardens Association).
"The effect of Smoke on Town Gardens."

9. MR. ARTHUR G. RUSTON, B.Sc. (of Leeds University).
"Air pollution by Coal Smoke and its effects on Vegetation."

Wednesday, March 27th, 1912.

Section B. Smoke Abatement.

11 a.m.

"Work done and to be done in organising preventive action."

CHAIRMAN
SIR WILLIAM RICHMOND, K.C.B., R.A.

10. HERR INGENIEUR NIES (Chief Engineer Hamburg Smoke Abatement Society).
"Progress of the Smoke Abatement movement in Germany."

2.30 p.m.

"The Physics of Smoke Abatement Apparatus and practical expedients for the abolition of Smoke, both industrial and domestic."

CHAIRMAN—
CAPTAIN H. RIALL SANKEY, R.E. (ret.), M.I.C.E., M.I.M.E.

18. PROFESSOR W. R. HODGKINSON, F.R.S., Ph. D., F.I.C.
"Smoke Abatement with special reference to the smokeless production of Steel, and Domestic Heating."

Wednesday, March 27th, 1912—continued.

11 a.m.

11. MR. THOMAS E. DONNELLY (Chairman of the Smoke Abatement Commission of Chicago).
"Smoke Abatement in America."

12. MR. Z. A. WILLARD (Boston).
"The Smoke Problem in the United States of America."

13. BAILIE W. SMITH (Convener of the Air Purification Sub-Committee of Glasgow).
"Should the Domestic Smoke nuisance be any longer tolerated."

14. MR. J. B. C. KERSHAW, F.I.C., F.S.S.
"Notes on recent progress in the Campaign against Black Smoke in this country."

15. MR. W. NICHOLSON (Chief Smoke Inspector for the City of Sheffield).
"Smoke abatement from the Inspector's point of view.

16. DR. R. C. BENNER, Ph. D.
"Smoke Abatement in Pittsburgh."

17. PROFESSOR C. W. A., VEDITZ, Ph. D., LL.B. (Pittsburgh University).
"Tentative Outline for an Investigation into the Economic Phases of the Smoke Problem."

2.30 p.m.

19. DR. J. S. OWENS, M.D., A.M.I.C.E.
"Wasteful Power Production.

20. COMMANDER W. F. CABORNE, C.B.. R.N.R., F.R.A.S., F.R.G.S.
"Stoking."

21. MR. W. D. SCOTT-MONCRIEFF.
"Solid Smokeless Fuels."

22. MR. GEORGE A. GOODWIN, M.I.C.E., Whit$^{th.}$ Sch$^{r.}$
"Suction Gas Plants."

23. DR. KOBBERT (Director of the Gas Works, Konigsberg).
"A Note on the German Smoke Crusade."

24. MR. JOHN S. PEARSON, M.I.Mar.E.
"Hand-fired Boilers; Qualification of Stokers; Overloading of Steam Boiler Plants."

Thursday, March 28th, 1912.

Section C. Law and Legislation.

11 a.m.

Proposed New Legislation.

CHAIRMAN—

MR. JULIAN S. CORBETT, LL.M., F.S.A.. (Chairman of Conference Committee.)

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25. MR. JOSEPH HURST, Barrister-at-Law.
"The Smoke Evil. Is further legislation necessary? If so, what should be its aims?"

26. PRINCIPAL GRAHAM (President of the Smoke Abatement League.)
"The League's proposed Smoke Abatement Bill."

5 p.m.

The existing Law and its administration abroad.

Proposed Royal Commission.

CHAIRMAN—

LORD JUSTICE FLETCHER MOULTON, F.R.S.

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27. MR. JULIAN S. CORBETT, LL.M., F.S.A., (Barrister-at-law.)
"Smoke Abatement Laws in other Countries."

28. DR. H. A. DES VOEUX, M.D. (Hon. Treasurer of the Coal Smoke Abatement Society).
"A plea for the appointment of a Royal Commission."

Delegates attending the Conferences are invited to attend the following Lectures and "At Homes."

LECTURES.

Monday, March 25th, 1912,

At 6 p.m.

PROFESSOR VIVIAN LEWES, F.I.C., F.C.S.

Lecture on "The Relation of the Gas Industry to Smoke Abatement."

Wednesday, March 27th, 1912,

At 5.30 p.m.

MR. FRANK BAILEY, M.I.C.E. (Engineer and Joint Managing Director, City of London Electric Lighting Co., Ltd.).

Lantern Lecture on "Electricity, Lighting, Heating and Power."

Tuesday, April 2nd, 1912,

At 8 p.m.

DR. JOHN S. OWENS, M.D., A.M.I.C.E.

Lantern Lecture on "Coal Smoke and its Abatement."

"AT HOMES."

(In the Pavilion of the Coal Smoke Abatement Society)

Monday, March 25th, 1912,

At 4 p.m.

MR. R. G. SHADBOLT (President Institution of Gas Engineers).

Wednesday, March 27th, 1912

At 4 p.m.

MR. S. Z. de FERRANTI (President, Institution of Electrical Engineers).

Tuesday, April 2nd, 1912,

At 4 p.m.

DR. H. A. DES VOEUX (The Hon. Treasurer of the Coal Smoke Abatement Society) and Mrs. Des Voeux.

GENERAL ARRANGEMENTS.

Proofs of Papers. Proofs of Papers will, as far as possible, be issued beforehand with the object of facilitating practical and useful discussions.

Absentee Authors. At the discretion of the Chairman, Papers, the authors of which are not present, will be taken as read.

Time Allowed to Speakers. In cases of Papers which would take more than 15 minutes to read, contributors are requested to substitute a short explanation which will not occupy more than that period to deliver.

The opportunity for general discussion of Papers must depend upon the time at the disposal of the Meeting, but after the whole of the Papers allotted to each sitting have been introduced by the authors, subsequent speakers will be allowed 10 minutes each until the last half-hour of each Session available for general discussion, when at the option of the Chairman the period will be reduced to five minutes.

Gentlemen desirous of taking part in the discussion are requested to hand in their names to the Secretary at or before the commencement of each Session.

At the discretion of the Chairman, openers will be allowed facilities for replying to the discussion.

Resolutions In order that the maximum amount of time may be available for the consideration of the various Papers, and in view also of the full programme drawn up, Resolutions will only be taken at the closing Session on Thursday, March 28th, at 5 p.m.

No Resolution can be proposed unless a copy has been previously sent to the Secretary or handed to him not later than Thursday morning, the 28th March.

Re-Publication of Papers. The Conference Committee and the Coal Smoke Abatement Society, or either of them, reserve to themselves the privilege of reprinting any Paper, either in whole or in part, or of refraining from the subsequent publication thereof if they see fit.

It is the intention of the Society to have a copy of the Papers, together with a Report of the proceedings of the Conferences, bound and forwarded to each delegate.

Refreshments. Arrangements have been made by which refreshments can be obtained in the ordinary refreshment room of the Hall, in the special "Electricity Hall," and in the "Gas Companies' Pavilion."

JULIAN S. CORBETT, Chairman.
R. LESSING, Hon. Secretary.
LAWRENCE W. CHUBB, Secretary.

All communications despatched *before the 26th inst.*, in regard to the Conference Committee should be forwarded to Mr. L. W. Chubb, Secretary of the Coal Smoke Abatement Society, 25, Victoria Street, Westminster, S.W. Communications sent on the 26th, 27th, and 28th inst., may also be addressed to Mr. Chubb, to the special office of the Society at the Exhibition.

C 6854

Patents and Designs Act, 1907.

Upon the application of Mr. F. W. Bridges, of Balfour House, Finsbury Pavement, London, E.C., made to the Board of Trade on the 16th day of August, 1911, the Board of Trade do hereby certify, for the purposes of the Patents and Designs Act, 1907, that the International Smoke Abatement Exhibition, proposed to be held in the year 1912, at the Royol Agricultural Hall Islington, in the County of London, is an Industrial Exhibition.'

Signed, by order of the Board of Trade, this 23rd day of August, 1911.

GEO. J. STANLEY,
An Assistant Secretary to the Board of Trade.

PART I. PATENTS. Provisions as to Exhibitions.

SECTION 45 (1). The exhibition of an invention at an industrial or international exhibition, certified as such by the Board of Trade, or the publication of any description of the invention during the period of the holding of the exhibition, or the use of the invention for the purpose of the exhibition in the place where the exhibition is held, or the use of the invention during the period of the holding of the exhibition by any person elsewhere, without the privity or consent of the inventor, shall not prejudice the right of the inventor to apply for and obtain a patent in respect of the invention or the validity of any patent granted on the application, provided that:—

(*a*) The exhibitor, before exhibiting the invention, gives the Comptroller the prescribed notice of his intention to do so; and

(*b*) The application for a patent is made before or within six months from the date of the opening of the exhibition.

PART II. DESIGNS. Provisions as to Exhibitions.

SECTION 59 (1). The exhibition at an industrial or international exhibition, certified as such by the Board of Trade, or the exhibition elsewhere during the period of the holding of the exhibition, without the privity or consent of the proprietor of a design, or of any article to which a design is applied, or the publication, during the holding of any such exhibition, of a description of a design, shall not prevent the design from being registered, or invalidate the registration thereof, provided that:—

(*a*) The exhibitor, before exhibiting the design or article, or publishing a description of the design, gives the Comptroller the prescribed notice of his intention to do so; and

(*b*) The application for registration is made before or within six months from the date of the opening of the exhibition.

GAS AS A MEANS TO THE END OF SMOKE ABATEMENT.

The present time is certainly a particularly appropriate one for discussing alternatives to the use of coal.

Gas cannot strictly be spoken of as a substitute for coal, as it, of course, requires coal for its manufacture, but the conversion of coal into gas, plus coke, plus tar, plus sulphate of ammonia and plus many other valuable bye-products, is a far more economical and hygienic way of using coal than by burning it in its crude form in grates or kitchen ranges and pouring forth a large proportion of the bye-products into the atmosphere, to its serious defilement.

It is of interest to note that there is absolutely no waste in a gas works. Coal goes into the works and nothing comes out except what is useable and saleable. There is no useless residuum whatever.

To those interested in Smoke Abatement, it is hardly necessary to point out the many advantages to the community of having coal distilled at the gas works and its purified essence delivered ready for use at hearth, range, or boiler, with the smokeless residue (coke) available as an alternative fuel which is especially useful where continuous heating is required (as in laundries, greenhouses, etc.) ; while the tarry matter, which so materially helps to form smoke when coal is burnt in its crude form is available for (amongst many other hygienic purposes) the prevention of the dust nuisance on the roads.

If we can purify our atmosphere by burning gas instead of coal on the one hand, and utilising the tar bye-products of gas-making to prevent its pollution by dust on the other hand, we shall have gone a long way to benefitting the health of the community.

It is, therefore, a matter for much congratulation that the use of gas for fuel has increased very rapidly in recent years.

Cooking by gas has been firmly established and very widely adopted for many years, though until comparatively recently, the use of gas for cooking in the home was largely restricted to the summer months—when there is no occasion to light the kitchen coal fire for the purpose of warming the kitchen as well as heating the hot water supply. Moreover, the question of hot water in the summer has, until late, been an obstacle to the exclusive use of gas for cooking even during the summer. There now, however, remains no reason why gas should not be used—as in many houses it is being used—exclusively for cooking all the year round.

The system of installing coke-heated boilers for providing the hot water supply of the household throughout the year, and of providing warmth for the kitchen during the winter, has proved to be a great success, both from the point of view of economy and that of comfort and convenience.

The following quotation from a speech made by a satisfied user of this type of apparatus, at a Conference of the Coal Smoke Abatement Society will be of interest in this connection :—

> "Eight years ago, I installed a Coke Boiler and each year I am more satisfied with it. It has given a magnificent hot water supply throughout the house at a temperature of 170° F., and the supply has been so plentiful that I have been enabled to put on their hot water radiators in passages . . . . . . With a gas cooker and a coke boiler,

the difficulties of a hot water system and the warmth of the kitchen are surmounted. If this system were installed in all houses in London, the greater part of the smoke from private houses would be prevented."

Another London member of the Coal Smoke Abatement Society has had practical experience of the system, and writes as follows:—

"The fixing of the Coke Boiler in this house (which has a particularly cold and damp basement) in conjunction with a gas cooker has worked a revolution in the kitchen quarters. I have a very large family of children, and the perfectly heated bath appliances have made almost incredible improvements in the arrangements both in sickness and in health.

"From a practical housekeeper's point of view, I should like to add a few words with reference to the cost of running the boiler.

"It is satisfactory to note that this has been, consistently, well below the sum which was guaranteed as an averege for the year. The gas cooker and coke boiler together have, over a series of years (during which careful records have been kept), cost slightly less than a large coal range which never gave us effective hot water supply; while, largely owing to the installation referred to, I have not only been able to keep a very much valued cook, who is over sixty, but, owing to the smoothness with which our labour saving appliances have done all that was claimed for them, I have had no change of servants since.

"From a hygienic point of view, my cook finds that one of the great advantages of your boiler is that all refuse can be easily burnt—a very important point where there is no coal range."

Where, however, there is neither space nor necessity to instal a coke-heated boiler, the hot water supply throughout the period of the year when the kitchen fire is not otherwise required can quite satisfactorily be provided for, either by a gas-heated boiler connected with the circulation system or by gas-heated apparatus of the type of the geyser or califont.

There is, therefore, no reason why gas should not be the universal fuel for cooking in summer, nor, in regard to the majority of households, why it should not be adopted for exclusive use throughout the year.

The consequent effect upon the atmosphere of London would be enormous.

On this subject of cooking, mention must be made of the great boon to the working classes and the great advantages to the atmosphere of London that have been brought about by the introduction of the penny-in-the-slot meter, and the adoption by the working classes of London, through this means, of gas for cooking to a very wide extent. It is interesting to note that one of the heaviest demands for gas with which the London Gas Companies now have to cope is the demand between the hours of 11 and 1 o'clock on Sunday morning, when the wives of the working population of London are cooking their Sunday dinner.

Apart, however, from the effect of this wide adoption of gas for cooking upon the air of London, much has been done—though still more remains to be done—in the direction of substituting gas fires for coal fires in the home and business premises of London.

The following figures in regard to growth in the use of gas cooking and heating stoves in the metropolitan area will be interesting:—

Gas heating, cooking and hot water appliances sold, hired or loaned to their consumers by the Metropolitan and Suburban Gas Companies:—

At end of 1891	46,000.
,, ,, 1896	223,000.
,, ,, 1901	445,000.
,, ,, 1906	989,000.
,, ,, 1911	1,494,000.

For many years, the general adoption of gas fires in place of coal fires, was hindered by the prejudice entertained in many quarters against the use of gas for heating living rooms and bedrooms—a prejudice which had its foundation in the many badly-constructed gas fires that were placed upon the market, and the indifferent way in which many well-constructed gas fires were fixed by fitters ignorant of the fact that the fitting of a gas fire is a job that calls for careful consideration of chimney draught conditions, as well as merely the laying of the gas supply in a sound manner.

That there was no other reason why gas fires should not have been more generally adopted in years gone by, was clearly proved by the report based on the exhaustive tests which were made by the special Analytical Sanitary Commission appointed by the "Lancet" in 1893.

The following is an extract from that report, which is an authoritative document prepared by recognised authorities on hygienic questions:—

> "Most minute tests failed to find any deleterious products in the air of the room, in spite of the fact that no special precautions were taken to ensure ventilation . . . .
>
> "Summing up the evidence gained from the entire results of the investigation, we are induced to express the opinion that gas can be used for warming purposes efficiently without prejudice to health, and without the formation of fog-forming constituents or air-contaminating products . . . . .
>
> "In dismissing this important section of the subject, it only remains to point out the manifold advantages of gas over coal fires—advantages, however, which are only too obvious to need description. None will deny the convenience of the system. With gas, a bright hot fire can be obtained at any moment, night or day; the heat can be regulated to a degree, the fire can be stopped at will, conveyance of coal can be dispensed with, and the often-times troublesome and clumsy process of lighting with wood and paper is avoided, while cleanliness is an inevitable result of gas installation."

This report received full confirmation as a result of a further investigation of the subject carried out on behalf of the Coal Smoke Abatement Society by two eminent medical men, assisted by chemical experts. Their report, published in the *Lancet*, of 17th November, 1906, contained the following announcement:—

> "A properly constructed gas stove, with a flue sufficiently large to carry away the products of combustion, although, for constant work, more costly than a coal fire, is quite as satisfactory from a hygienic point of view, and does not in any way vitiate the air of the room, nor does it produce any abnormal drying effect, as is popularly supposed. It will carry off from about 2,000 to 4,000 cubic feet of air per hour, and this is a valuable ventilating effect. . . . . . .
>
> "This does not necessarily mean that gas is always more costly than coal; other factors must be considered, such as the rate at which the room is warmed. It was found that while the gas fires usually produced a fairly steady temperature in the rooms in from one to two hours, the coal fires took much longer.
>
> "Another point in favour of the gas fires is that they can be easily regulated and the heat of the room controlled in a way which is not possible with coal fires."

These two scientific investigations have resulted in a very large number of medical men adopting gas as a means of heating, and it is true to say that a large majority of practitioners in London not only fully approve this method of heating, but are themselves satisfied users of gas fires.

The following quotation from the letter of a well-known London "M.D." is of interest in showing how a modern gas fire, properly fitted, can convert a scientific medical man from a strongly held prejudice against, to an equally strong advocacy of, gas fires:—

> "After all the trouble taken by your representative, to satisfy me I should be ungrateful if I did not express my satisfaction. As I told you before the work was undertaken, I was by no means in favour of gas fires; and I still see in other houses gas fires which are obviously insanitary.

"But I am more than satisfied with those installed both in my private house, 10 in number, and two in my consulting rooms. It may be of use to you to quote my experience.

"Not one of these fires give the slightest smell, and careful tests show that no burnt gas escapes into the rooms. We have had no complaints of headaches or sleepiness all through the recent cold snap when the fires were busily burning.

"The absence of dust from the rooms is much remarked and the economy in labour is great. Gas undeniably costs more per hour than coal, but when the wages of a servant, to say nothing of her keep, are set off the balance is much in favour of gas.

"In a sick room the gas fire is noiseless, dustless, and the heat can be graduated to a nicety.

"To those who sit up late reading, the gas is a great advantage as it needs no attention, and instead of going chilly to bed having sat over the dying embers, I turn the gas full on and have a good warm up the last thing.

"The amount of heat given out is of course uniform. In this one does sometimes miss the roar and blaze of a coal fire which can be procured at will, but it seems to me that the general atmosphere of the room is warmer where a gas fire has been burning than where a big coal fire has made the centre of the room very hot. It may be a matter of contrast.

"There is however a big 'but.' I must warn any who think of adopting gas fires that they must insist that only the Gas Company's own men shall set them up. I thoroughly realised the importance of this when I compared the work done in my house with that done by 'local ironmongers.' It is a skilled job. I would say 'Get the Gas Company to do the work and pay a small sum for periodical inspection.' This inspection is important because servants will now and then dislodge the fuel.

"You are welcome to quote this letter, but my name must not be published. To a limited extent also I should not object to letting people see the fires at work in my house."

These three extracts will probably serve to remove any lingering doubts from the minds of those who can see the comfort and convenience to be secured by the use of gas fires, but hesitate to adopt them on hygienic grounds.

There would be no difficulty in adding a very large number of similar expressions of opinion to the foregoing if they were not regarded as conclusive by anyone investigating the subject.

Briefly it may be said that a gas fire is a purified coal fire, which, properly fixed, is more hygienic than a coal fire so far as the room in which it is used is concerned, and vastly more hygienic than a coal fire in regard to its effect upon the outside atmosphere.

In considering the influence of the use of gas for fuel upon the atmosphere of London, sight must not be lost of the extent to which gas has displaced smoke-producing fuel in various manufacturing and industrial processes.

The Royal Mint, the principal newspapers, the leading assayers, and a host of other important industrial undertakings could be quoted as instances where gas fuel has been found preferable to coal, both in regard to economy and convenience; as well as, of course, in respect to cleanliness within and without the premises where it is used.

The steady spread of the use of gas fuel for domestic and industrial purposes affords good ground for hope that the improvement of the atmosphere of London which has been noticeable of recent years, will continue to grow until a really smoky fog will at last become a thing that will have existence only in the memory of "the oldest inhabitant."

M.A.C.B.

Electricity as a Smoke Abater.

By A. F. Harrison.

I HAVE been asked by the Organisers of this Exhibition to write a short article on the subject of "Electricity as a Smoke Abater," but I hope I shall not be considered to have exceeded instructions if I write of "Electricity as a Smoke Vanisher." Indeed, it is quite impossible to do less, and it would only be fair to electricity to carry the argument much further, for electricity never makes anything more or less than the exact amount of light, heat or power required by the user.

Perhaps, however, if I pursued this argument, I should be going beyond the territory occupied by the Coal Smoke Abatement Society and I will therefore keep to my first proposition. The position of electricity in the good work of "Smoke Abatement" can be made quite clear in a very few words. The manufacturer who uses electricity for driving his machines; the householder who uses electric radiators for the heating of his rooms; the cook who uses electric heat in the preparation of delicacies, requires no flue in connection with his apparatus, and therefore, need have no unsightly chimney or smoke stack sticking out above the roof of his premises, and where there is no chimney there is no smoke. To digress for a moment—let us picture a London of blue skies and no smoke, and try to imagine what our architects will provide for us when they are no longer obliged to provide for our smoke.

On any dull day in London, when conditions are favourable for the fog fiend, a murky cloud of smoke floats overhead, and on ascending to an upper floor one may observe the spectacle of countless thousands of chimney pots each doing its best to render the air of London unbreathable, and certainly succeeding in the manufacture of a funereal pall, which is a dispiriting and pitiful sight, inasmuch as the means are at hand by which it might be dispelled for ever.

It is a common thing for the London householder, whose attention is called to such matters, to reply "Ah, but it is the factories which cause the London fogs," and forthwith he proceeds with poker and shovel to add his own quota. But, like many other things, this is a common error. Most London factories have been converted to the right view, partly, perhaps, because it was also the most profitable, and although their chimneys may still be standing, they are but silent witnesses of time gone by for ever. Doubtless, our "cock-sure" friend would say, "See what splendid work that Coal Smoke Abatement Society is doing! Look how they've made that fellow consume his own smoke! I really must send them a subscription."

Unfortunately the electric supply people cannot claim donations. They must carry on a perpetual warfare against ancient methods and pay for it themselves, but they can at any rate, claim credit from all good Smoke Abaters for the work already achieved, and support for the vastly greater work that yet remains to be done.

The particular "penny-a-liner" who is now addressing you, can claim some knowledge of what has happened in Fleet Street within the past ten or twelve years. There are congregated, some of the largest, and, I am sure I may say without fear of contradiction in The Press, the most important printing works in the world. The whole district resounds with the unceasing clangour of printing machinery, but there is not one of real importance that is not worked entirely by electricity—save one—and that a semi-penitent destined ere long to acquire virtue. The same story may be told

of other trades and in particular of the great cold storages wherein London's food is kept frozen in all weathers. But this is not all, for the ease with which an electric motor may be set up has led to a revival of the small workshop and even to the development of various manufactures and processes which formerly went further afield. All these are being added to the advantages of London's traders and without any disadvantage to London's inhabitants.

Now the real producers of fog are not factories, but private houses. Few factory chimneys emit as much smoke at any time as a hundred private houses, and we know, that in London at any rate, the number of factories is vastly less than that would mean. It is the private house chimney that is mainly responsible for the creation of London fog, for despite the change that has been brought about in the factories, the London private house is still consuming nearly five million tons of coal a year and doing it in the most unscientific and dirty manner possible. The private householder is intensely conservative and clings with fervour to the old fashioned open grate, and to the pleasures connected with the national habit of toasting. He entirely forgets that this is a very expensive method of securing heat, entailing enormous labour in fetching and carrying, cleaning and sweeping which proceeds unceasingly throughout the winter months. If this were entirely abolished, as it is where Electric Radiators are used, there is little doubt that most householders would be able to do with a smaller staff of servants, and save expenditure on paint and curtains, &c.

This labour of fetching and carrying is a curious survival, and in many countries it has already disappeared. In America, our methods are regarded with surprise and amusement, for in that country the servant girl has long been freed from the coal scuttle. The "Edison Monthly" thus comments on an English poster issued to advocate Electric Radiators " . . . from these cartoons it now appears that the good old days are past and that the housemaid now rebels against carrying coals to the fourth floor front. The real marvel to American housewives, is that the housemaid remained submissive as long as she did."

Electricity will welcome the housemaid's revolt, but in the meantime it may bring about a peaceful revolution, for it may claim to be a source of great economy, since the wages and board of a single servant will pay the coal bill of any two average households. The idea is making slow but sure headway, and in the City, where one would naturally expect to find the correct result of 2 × 2, electric radiators are quite common objects, and the Supply Companies engaged in supplying electricity in the City are able to boast that they already have more than 5,000 connected to their mains, and more are being added every day.

Those Londoners who visit the Electricity Hall at this Exhibition will have no excuse for pleading ignorance as to the best means by which they can secure cleanliness and comfort in their own homes, and assist the work of the "Smoke Vanisher" by declining any longer to choke or poison either themselves or their neighbours.

Half Hour Lectures on Gas Cookery

as follows, will be given by the

Gas Light and Coke Company's Lady Demonstrators,

Questions invited at the close of each Lecture.

Saturday, March 23rd.

3.0 p.m.	Students' competition.
4.0 p.m.	How to bake pastry, and hints on roasting meats, short crust, fruit tart and sausage rolls.
6.30 p.m.	Competition.
8.0 p.m.	Use of the griller, toast, steak and omelette.
9.0 p.m.	The use of browning shelf, cornflour cakes and Victoria sandwich.

Monday, March 25th.

3.0 p.m.	Economical cooking by gas cooking, a quick breakfast.
4.0 p.m.	Afternoon tea-cakes, madeira cakes, cocoanut buns.
6.30 p.m.	Students' competition.
8.0 p.m.	Best method of using the gas stove for pastry and cakes ; plum cakes and scones.

Tuesday, March 26th.

3.0 p.m.	A little luncheon. Fried whiting, grilled cutlets, pudding.
4.0 p.m.	How to read meter and check waste. Home made bread and dinner rolls.
6.30 p.m.	Students' competition.
8.0 p.m.	How gas is wasted, wrongful methods for roasting and baking. Roast beef, Yorkshire, roast potatoes.

Wednesday, March 27th.

3.0 p.m.	Special points in selecting a gas stove. Scotch eggs and scones Grilled bacon and tomatoes.
4.0 p.m.	Afternoon tea-cakes of various kinds.
6.30 p.m.	Students' competition.
8.0 p.m.	Short crust, apple dumplings, flaky pastry, and sausage rolls.

Thursday, March 28th.

3.0 p.m. A quickly prepared luncheon.
4.0 p.m. Cherry cakes, queen cakes, and omelette.
6.30 p.m. Students' competition.
8.0 p.m. A quickly prepared little supper, showing the advantage of using gas as a fuel.

Friday, March 29th.

3.0 p.m. A quick luncheon. Grilled fish, Dresden patties, cheese pudding.
4.0 p.m. Cassolette pastry, fricasse of prawns, savouries.
6.30 p.m. Students' competition.
8.0 p.m. Best methods of cleaning stoves. Cornish pasties, macaroni cheese.

Saturday, March 30th.

3.0 p.m. Students' competition.
4.0 p.m. Use of griller, chops, omelettes, toasts, pancakes.
6.30 p.m. Students' competition.
8.0 p.m. How to bake pastry and roast meat. Roast lamb, fruit tart, chocolate creams.
9.0 p.m. Economical cooking by gas, a quickly prepared supper.

Monday, April 1st.

3.0 p.m. Best method of using gas stoves for pastry and cakes.
4.0 p.m. Use of the browning shelf, Madeira cakes, cocoanut buns.
6.30 p.m. Students' competition.
8.0 p.m. How to read meter and check waste. One or two Lenten dishes.

Tuesday, April 2nd.

3.0 p.m. How to choose a gas cooking stove. Roast chicken, fried potatoes pineapple creams.
4.0 p.m. Afternoon tea-cakes and Swiss roll.
6.30 p.m. Students' competition.
8.0 p.m. Home-made bread and rolls.

Wednesday, April 3rd.

3.0 p.m. A quickly prepared luncheon at small cost.
4.0 p.m. Cherry cakes, queen cakes and omelette.
6.30 p.m. Students' competition.
8.0 p.m. On the proper method of using the gas oven for roasting, baking, boiling, and grilling; how to read the meter A quickly prepared breakfast.

Thursday, April 4th.

3.0 p.m. Students' Final Competition, and Grand Distribution of Prizes, gold and silver watches, presented to the winners by the Gas Light and Coke Company.

PROGRAMME OF MUSIC.

THE GAS LIGHT & COKE COMPANY'S PRIZE BAND

(KILBURN BRANCH).

Hon. Conductor ... ... A. E. HORSTEAD, Esq.

Saturday, March 23rd, 1912.

3—5 p.m.

1	MARCH	"Resolute"	Moorhouse
2	VALSE	"The Druid's Prayer"	Gordon Davson
3	SELECTION from	"La Vestale"	Spontini
4	OVERTURE	"La Diademe"	Hermann
5	SELECTION of	Welsh Melodies	Arr. by Ord Hume
6	CORNET SOLO	"The Linnet"	Brockett
7	SELECTION from	"The Gondoliers"	Sullivan
8	INDIAN INTERMEZZO	"Rainbow"	Wenrich

GOD SAVE THE KING.

The time between pieces will not exceed five minutes.

Saturday, March 23rd, 1912.

7—9.45 p.m.

1	MARCH	"Fearless Footsteps"	Rimmer
2	OVERTURE	"Martha"	Flotow
3	SELECTION from	"Maritana"	Wallace
4	CORNET SOLO	"My dreams" (Soloist, Mr. W. HALSEY.)	Tosti
5	VALSE	"Inspiration"	Thomas
6	SELECTION of	Old English Glees	Various
7	SELECTION from	"William Tell"	Rossini
8	TWO SHORT PIECES	(a) "Rendezvous"	Aletter
		(b) "Clorinda"	Montagu Ring
9	EUPHONIUM AND TROMBONE DUET	"Excelsior" (Soloists, Messrs. CALLAGHAN & SMITH.)	Balfe
10	NATIONAL FANTASIA	"Songs of Scotland"	—
11	PATROL	"Irish"	Rimmer
12	GRAND DESCRIPTIVE FANTASIA	"A Soldier's Life"	Sheriff

ILLUSTRATING—The Reville—Orders for Abroad—Embarking—"Then you'll remember me"—Weighing of Anchor—"Farewell ye Portsmouth Town—At Sea—"Rocked in the Cradle of the Deep"—"The Bay of Biscay"—The Storm—Prayer during Storm—Fine Weather, and the Sailors make merry—Landing—March of the Grenadiers and Scotch Regiments—In Camp—Lights Out—Night—The Battle—Victory—"See the Conquering Hero comes"—The Return—"When Johnny comes marching home"—"Home, Sweet Home."

GOD SAVE THE KING.

The time between pieces will not exceed five minutes.

Saturday, March 30th, 1912.

3—5 p.m.

1	MARCH	"Enchanter"	White
2	VALSE	"Fleur de Luce"	Neilson
3	EUPHONIUM SOLO	"For you Alone" (Soloist—Mr. G. CALLAGHAN.)	H. E. Gheel
4	OVERTURE	"The King's Lieutenant"	Tit
5	SELECTION FROM	"Daughter of the Regiment"	Donizetti
6	CORNET SOLO	"Maise Mine"	Rimmer
7	INTERMEZZO	"The Cadet"	Haines
8	DESCRIPTIVE FANTASIA	"The Harvest Home"	Cope

Synopsis:—The Last Load—Merry Making—Farmer's Song "Welcome, ever Welcome, Friends"—Supper—The Toast "The Roast Beef of Old England—Ploughman's Song "The Farmer's Boy"—The Toast "Here's to the Maiden"—The Daughter's Song "When the Heart is Young"—The Dance and Finale.

GOD SAVE THE KING.

The time between pieces will not exceed five minutes.

Saturday, March 30th, 1912.

7—9.45 p.m.

1	MARCH	"Salute the Standard"	Safroni
2	VALSE	"The Old Abbey"	Rimmer
3	SELECTION from	"The Lily of Killarney"	Sir J. Benedict
4	OVERTURE	"Raymond"	Ambroise Thomas
5	PATRIOTIC SELECTION	"For King and Country"	—
6	FANTASIA	"Sunny Skies"	Rimmer
7	TWO PIECES	(a) "The Pilgrim's Song of Hope"	Baptiste
		(b) "Rose de La Pedrone"	Laitre
8	SELECTION from	"The Pirates of Penzance"	Sullivan
9	CORNET SOLO	"Rose softly blooming" (Soloist, Mr. W. HALSEY.)	Spohr
10	DESCRIPTIVE PATROL	"Turkish" (Illustrating the approach and passing of a Turkish regiment.)	Michaelis
11	SELECTION of	Irish Folk Songs	Various

GOD SAVE THE KING.

The time between pieces will not exceed five minutes.

STRING BAND of the 7th CITY OF LONDON BATTN.

THE LONDON REGIMENT.

BY PERMISSION OF COLONEL EKIN.

Conductor ... ... Mr. A. F. DAY.

Monday, March 25th, Thursday, March 28th, and Tuesday, April 2nd, 1912.

1	MARCH	"Austria"	Nowotny
2	WALTZ	"Septembre"	Godin
3	OVERTURE	"Mignonette"	Parker
4	SERENADE	"D'Amour"	Von Blon
5	TWO STEP	"The Mosquito Parade"	Whitney
6	SELECTION	"A Country Girl"	Monckton
7	MARCH	"La Mattchiche"	Birel Clerc
8	WALTZ	"Amoretten Tanze"	Gungl
9	ENTRACTE	"In the Shadows"	Finck
10	SELECTION	"The Belle of New York"	Kerker
11	INDIAN INTERMEZZO	"Rainbow"	Wenrich
12	TWO STEP	"The Cockney Band"	Valentin

GOD SAVE THE KING.

Tuesday, March 26th, Friday, March 29th, and Wednesday, April 3rd, 1912.

1	MARCH	"With Sword and Lance"	Starke
2	WALTZ	"Count of Luxembourg"	Lehar
3	OVERTURE	"Le Chevalier Breton"	Homan
4	A SUMMER IDYL	"Hiawatha"	Moret
5	INTERMEZZO	"Sezilietta"	Von Blon
6	SELECTION	"A Runaway Girl"	Caryll
7	MARCH	"Sons of the Brave"	Bidgood
8	WALTZ	"The Chocolate Soldier"	Straus
9	ENTRACTE DESCRIPTIVE	"March of the Mountain Gnomes"	Eilenberg
10	SELECTION	"Miss Hook of Holland"	Rubens
11	CHARACTERISTIC NOVELTY	"The Teddy Bears' Picnic"	Bratton
12	WALTZ	"The Dollar Princess"	Leo Fall

GOD SAVE THE KING.

Wednesday, March 27th, Monday, April 1st, and Thursday, April 4th, 1912.

1	MARCH	"The Invincible Eagle"	Sousa
2	WALTZ	"Venus on Earth"	Lincke
3	SALONTTUCK	"Das erste herz klapfen"	Eilenberg
4	JAPANESE ROMANCE	"Poppies"	Moret
5	TWO STEP	"Yip, I'addy, I'ay"	Higgs
6	SELECTION	"The Orchid"	Caryll
7	MARCH	"Distant Greeting"	Doring
8	WALTZ	"The Quaker Girl"	Monckton
9	INTERMEZZO	"Forget-me-not"	Macbeth
10	INDIAN TWO STEP	"Silverheels"	Moret
11	SELECTION	"The Spring Chicken"	Caryll
12	MARCH	"Under Freedom's Flag"	Nowvieske

GOD SAVE THE KING.

THE SCARLET AND GOLD ORCHESTRA

(Supplied by ALFRED PHILLIPS Ltd.)

Monday, March 25th, 1912.

At 3 p.m.

1	March	"Stars and Stripes"	Sousa
2	Valse	"Venus on Earth"	Lincke
3	Selection	"Gondoliers"	Sullivan
4	Morceaux	"Ein Liebeslied"	Powell
5	Chanson	"Come Sing to Me"	Thompson
6	Sketch	"Down South"	Myddleton
7	Overture	"Poet and Peasant"	Suppe
8	Valse	"Sylvana"	L. Martel
9	Morceau	"Aubade Napolitane	Aletter
10	Characteristic Novelty	"Teddy Bear's Picnic"	Bratton
11	Valse	"Regrets"	Wade
12	Sketch	"On the Missisippi"	Morse

Tuesday, March 26th, 1912,

At 3 p.m.

1	March	"Jolly Days"	Clark
2	Valse Lente	"Amoureuse"	Berger
3	Overture	"Morning, Noon and Night"	Suppe
4	Japanese Romance	"Poppies"	Moret
5	Valse	"Love and Life in Vienna"	Komzak
6	Two Step	"Bit o' Blarney"	Helf
7	March	"Gay Pierrots"	Dorel
8	Morceau	"Judese"	Gounod
9	Valse	"Sylvana"	Martel
10	Selection	"Carmen"	Bizet
11	Fantasia on Songs	-	Tosti
12	Two Step	"Hunky Dory"	Holzman

Wednesday, March 27th, 1912,

At 3 p.m.

1	March	"St. George"	Hill
2	Valse	"Reve D'Orient"	Giraud
3	Selection	"La Bohéme"	Puccini
4	Morceau	"Serenade"	Bridge
5	Valse Lente	"Tout passe"	Berger
6	Two Step	"Daddy Peg Leg"	Whitney
7	March	"Gladiators"	Fucik
8	Morceau	"Queen Mab"	Kaps
9	Selection	"Faust"	Gounod
10	Valse	"Sylvana"	Martel
11	Chanson—Cornet Solo	"When all the world is sleeping"	Adams
12	Two Step	"La Likette"	Gauwin

INTERNATIONAL

Smoke Abatement Exhibition

Royal Agricultural Hall, London, March 23 to April 4, 1912.

Exhibitors' Index.

	Stand No.
Anderson, D. & Co., 18-20, Farringdon Road, E.C.	70, 87
Babcock & Wilcox, Ltd., Oriel House, Farringdon Street, E.C.	20
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Bennis, Ed. & Co., Ltd., Little Hulton, Bolton	35, 48
Bilbie Hobson & Co., 106, Queen Victoria Street, E.C.	4
British Vacuum Cleaner Co., Ltd., Parsons Green Lane, S.W.	76, 81
Cannon Ironfoundries, Ltd., Deepfields, Bilton	58, 67
Carron Co., 15, Upper Thames Street, E.C.	6, 7, 8
Chemical Trade Journal, 265, Strand, W.C.	42
Coalexld, Ltd., Lulyland Street, Lancaster	13
Compagnie Francaise des Brevets-Schaller, Paris	23
Crosthwaite Fire Bar Syndicate, Ltd., 278, Birkbeck Bank Chambers, Holborn, W.C.	22
Davis, A. F., 2, Enfield Road, Kingsland, N.	45
Direct Gas Fuel Ltd., 17, Victoria Street, S.W.	90
Eagle Range and Gas Stove Co., Ltd., 127, Regent Street, W.	9
Ewart & Son, Ltd., 346, Euston Road, N.W.	56, 69
Falkirk Iron Co., Craven House, Kingsway, W.C.	113, 114, 115
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Haughton's Patent Metallic Packing Co., Ltd., 30, St. Mary-at-Hill, E.C.	33, 50
Hill, J. & P. Ordnance Works, Sheffield	118, 119, 120
Hodgkinson, James (Salford), Ltd., Manchester	78, 79
Hoek's, N. V., Gashaardenfabrik, Den Haag	15a
Hutchings, G. J., 116, Blackfriars Road, S.E.	106a
Interoven Stove Co., Ltd., 78, Great Queen Street, Kingsway, W.C.	14
Jelly & Co., Oxford Street, Leicester	21
John, J. A., Ltd. (Incorporated in Germany), 73, Camden Road	46
Kowitske, H. & Co., Berlin	106d
Leyton Timber Co., High Road, Leyton	106c
Löfquist, Hjalmar, Stockholm	110
London Warming and Ventilating Co., Ltd., 20, Newman Street, W.	109
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Exhibitors' Index—*continued.*

Joint Exhibit by the London Electric Supply Authorities and various manufacturers of Electrical Apparatus, in the Electricity Hall, The Arcade, near the Entrance.

Index to Advertisers.

Electrical Section.

Upon passing the turnstiles at the Upper Street Main Entrance the Visitor enters a draped passage-way brilliantly lighted by a series of white flame "Excello" arc lamps. These are the well-known lamps manufactured by the Union Electric Company, and a further large number of them is employed in the lighting of the Main Hall.

Little more than half-way up this passage (for it slopes upwards to the level of the Hall) the eye is arrested by a striking illuminated electric sign extending an invitation to enter

The Electricity Hall

in which will be found a comprehensive collection of deep interest to all, and in particular to the private householder. It should perhaps here be explained that the Electricity Hall has been organised by the Electric Supply Publicity Committee, a body formed some two years ago for the express purpose of supplying information to the public regarding the various uses of Electricity. The beautiful simplicity and easy convenience of Electricity when applied to heating and cooking and its cost-reducing properties as a power agent are destined to produce a revolution in every walk of life, but, as is only natural, people who do not understand Electricity in a technical sense are apt to overlook the beneficial changes that may be wrought by its aid.

Exhibitions to demonstrate the advantages of Electricity as a lighting and power agent have been held many times and the result is apparent in the almost universal use of Electric Light, wherever it may be obtained, and in the rapidly advancing wave of enthusiasm for the electric motor in the factory. Naturally electric power has made the greatest strides in districts where coal is least easily obtained, hence the comparative absence of unemployment in London workshops during the present coal crisis while factories in the coalfields districts have been closed down entirely. A London evening journal recently called attention to this remarkable fact, and reprints of the article may be obtained at the Publicity Committee's Stall. It is well worth reading and contains for the thoughtful mind much suggestive matter bearing upon the social problems of the future. 10

The Electric Supply Publicity Committee therefore decided upon this occasion to concentrate its energies upon the formation of an exhibit which should appeal most strongly to the householder and his wife and daughters who have to run the house for him. It must not be forgotten that this Exhibition is held in the interests of the Coal Smoke Abatement Society, and that its main object is to induce householders to adopt one or other of the many means at hand for reducing the appalling quantity of dirt, smoke, and poisonous vapours which are daily permitted to pollute the air of London and big cities. In pressing the claims of Electricity the Electric Supply Publicity Committee are putting into your hands information concerning that which not only reduces but absolutely abolishes all pollution of the atmosphere, for

Where Electric Heat is used there are No Products of Combustion at all.

With this introduction we will proceed on a tour of examination. The first thing to attract our attention will probably be the exceedingly soft yet abundant lighting of the hall, carried out entirely with metallic filament lamps placed in inverted bowles down the centre and in holophane cut-glass shades elsewhere. Light reflected from the ceiling is the "latest thing" and there is no doubt that it is also the best; no brilliant points to dazzle the eyes, and yet a soft mellow effulgence everywhere akin only to the effect of standing in summer sunshine with one's back to the sun.

Pausing for a moment as we enter we shall notice that the hall (it is usually known as King Edward's Hall) has been divided into several departments, and each is distinguished by an electric sign which at once defines its purpose and contents.

On our left is the

Electric Restaurant

and if it be meal time we will commence operations by consuming, probably for the first time in our lives, food actually cooked by electricity. If we know what's what in the art of cookery it will be a sad mischance if we are not willing, after this experience, to admit the high superiority of the fare placed before us. The sceptic will at once remark, "This is all very well, but electricity wants knowing, and an ordinary cook would come an awful howler with it." Sir, while you smoke your cigarette will you allow Madame to step across and watch the cooking, which is done in full view of the restaurant's customers. She will notice that the cooking appliances in use are all of the small household type and not those which would be expected in a restaurant. This has been done advisedly in order to show to ladies interested in the matter the practical results that they may obtain for themselves. On enquiry, she will learn that none of the cooks had operated an electric cooker up to ten days before the opening of the Exhibition; there cannot, therefore, be anything very mysterious about electric cooking. A word to the restaurant manager will secure the privilege of entry to the kitchen for the purpose of inspecting the operations at closer range.

The scullery is not usually an interesting spot, but here it is well worth a visit in order to see the electric "Therol" delivering water at any temperature desired, from "stone cold" to "superheated steam." In appearance it is a particularly cold-looking white-coloured tank. The electric knife-cleaner and potato-peeler should also be noted.

We must not leave the restaurant without acknowledging that our meal has been rendered all the more pleasant by the programme of music characteristically rendered by the

Russian Balalaika Orchestra.

Passing to the

Cooking Section

there are ranged for our inspection specimens of all the various kinds of electric cooking utensils with an attendant in charge to explain their working and supply any information we desire. It is interesting to handle these things and acquire a first-hand familiarity with them, but in order to retain a real knowledge we make a note to obtain from the Publicity Stall a good selection of literature upon the subject; and, for the beginner, a series of miniature lectures by Mrs. Cross, a lady who knows all about cooking with coal and gas as well as electricity, and is a converted enthusiast in favour of the latter, will be of intense interest. Electric cooking is no longer in its infancy, and another fascinating pamphlet gives an illustrated description of a large electric kitchen which is supplying the daily needs of hundreds of employees in the service of a big London drapery establishment in the form of fourpenny lunches. It is quite certain that this kitchen is not worked electrically for the sake of advertisment and the only possible alternative is Economy.

It will not be out of place here to mention that the new "Polytechnic," of which we have heard so much lately, is equipped with a large kitchen where the sole heating nd cooking agent is electricity.

The selection of literature that we shall obtain will tell us how and why cooking by electricity is better than cooking by any other method, and, with this in our pockets for perusal at leisure, we need not enter upon details here. At the Publicity Stall we can obtain particulars of the various lectures to be given during the run of the Exhibition, and, on a return visit, to hear one or more of these lectures will be well worth the trouble.

Continuing our inspection we come next upon

The Heating Section

where we find electric radiators and convectors of all kinds assembled, and a demonstrator ready to set any of them working for our edification. Again we remind ourselves that these handy things can be placed anywhere, that they produce nothing whatever except heat and require no attention. The financier of the party will at once see that in most houses the labour of cleaning and polishing grates, laying, lighting and attending to fires, shovelling and carrying coal, is sufficient to account for at least one servant whose board and wages would more than pay for the electricity consumed in heating, and in that case the profit and loss account will show a handsome credit balance composed of the present coal bill, the worry of keeping a stock sufficient to provide against miners' and transport workers strikes, and the damage to decorations and hangings caused by the products of combustion which are entirely absent where electric heating is employed.

Thus the householder who adopts electric heating will be his own best friend and the most efficient "Smoke Abater" that the Organisers of this Exhibition could desire to enrol.

A large assortment of makers' catalogues profusely illustrated with designs to suit all tastes and pockets, and various pamphlets dealing with the subject may be had on application to the Publicity Stall.

We next reach a little

Model Laundry

working entirely by electricity. A laundry does not usually form part of the establishment of a private house, but ironing work is a necessity everywhere, and this exhibit is designed for the purpose of demonstrating in a practical manner the advantages of the electric iron. In America it would be considered a foolish waste of space to trouble about exhibiting an article which is regarded as an intimate necessity everywhere, but in England the electric iron has not yet reached that position, and the advantages of an iron which is never dirty, never soils the linen to which it is applied, and retains its heat throughout the period of use have still to be demonstrated and explained. Ironing is essentially a domestic occupation, one in which the lady of the house may exercise her natural skill and lightness of touch, and an electric iron which may be attached to any available lampholder is the easiest was of becoming acquainted with the cleanliness and convenience of electric appliances.

Opposite the laundry, we find the stall of

The Electric Supply Publicity Committee

where we may obtain literature and catalogues dealing with any subject in which we may feel interested. This stall is in truth the centre of the Electricity Hall for, if we do not trouble to look at anything else, we can here obtain all that is necessary to provide us with more than a superficial knowledge of the comfort and luxury combined with true economy that may be secured by the employment of electricity in the service of man and woman.

We complete the circuit of the Electricity Hall with a visit to the **Miscellaneous Stall** where are exhibited other electric appliances of labour-saving tendencies but not necessarily connected with the application of heat. Electric fans have already woy their way to popular favour and most people are aware that these fans are driven bn small electric motors, but they have not realised the obvious fact that these same little motors may just as easily be used in many other ways. The electric vacuum cleaner is a vast improvement on the old fashioned carpet broom. It sucks the dust up and carries it away without leaving anything behind to re-settle on the furniture, and in so doing it pulls the pile of the carpet or the upholstery back into position and thereby

restores its original appearance. It requires no vigorous pushing and consequently the cleaning it done much more thoroughly because it becomes an interesting instead of a wearisome occupation. The electric knife cleaner, the boot polisher and the buffing machines all do away with the vexatious necessity for tiring armwork on the part of the domestic staff and leave no possible excuse for unsatisfactory results. The electrically driven sewing machine releases the eye and hand for concentration on the accuracy of the needle and the work produced is consequently much superior. There is in fact no department of work in which energy is required where electricity cannot effect improvement in conditions both for the worker and the work and, as we look forward into the Future where we see the development of civilisation ever demanding greater services from man to man and labour troubles ever assuming a more threating aspect, we shall be the more convinced that the true solution of these difficulties is in that wonderful energy that never refuses to respond to any call for service.

Electricity.

We have now concluded our tour of the Electricity Hall, but it is to be hoped that we have but begun our aquaintance with electricity, which as we have seen is capable of simplifying the daily problems of domestic life, bring comfort, cleanliness and economy.

The abolition of dirt and of laborious cleaning operations, the greater comfort of the domestic staff in a kitchen where excessive heat is unknow, the relief from all anxiety as to the contents of the coal cellar and the violent fluctuation of the coal market in times of industrial strife, the reduction of expenses that must of necessity follow where less work is to be done and the saving effected in household bills all point the way to a happier state of things. Added to all this, we shall be doing our duty as citizens and contributing to the Common Weal by adopting electricity for all the purposes demonstrated at this Exhibition and we shall deservedly earn the warmest approval of tne **Coal Smoke Abatement Society.**

Loan Exhibits.

Lent by the **Coal Smoke Abatement Society,** 25, Victoria Street, Westminster.

(*a*) Collection of photographs, charts, diagrams and reports of tests of grates and gas fires, illustrating the work of the Society.

(*b*) Group of comparative models illustrating the volume of the annual London sootfall. [76,050 tons.]

The centre model of Cleopatra's Needle is 17 ft. high and represents the volume of soot. The other models—Cleopatra's Needle and the Clock Tower of the Houses of Parliament—have been prepared to scale and show the space occupied by the volume of soot when compared with those structures.

(*c*) A soot guage.

The guage is one of those actually used in the Lancet experiments for determining the London sootfall. The guage is a hopper or a wide funnel measuring at the top 2 ft. square, terminating in a narrow tube below, connected with a capacious bottle. The collected rain and solid deposits were examined monthly.

(*d*) Collection of photographs to show the results of the well-known experiments, conducted by Professor Cohen and Mr. A. G. Ruston of Leeds University, to ascertain the effect of Smoke on plant life.

Lent by **Metropolitan Public Gardens Association,** 83, Lancaster Gate, W.

Unwashed shrubs showing the effect of London smoke.

A Collection showing the effect of Smoke on Canterbury Cathedral. Lent by **Mr. W. D. Caror, M.A., F.R.I.B.A., F.S.A.,** Cathedral Architect.

Diagrams showing the growth in the use of gas appliances in London during the past twenty years. Lent by **The Coal Smoke Abatement Society.**

Gauge for measuring soot fall. Lent by **The Gas Light & Coke Co.,** Horseferry Road, London, S.W.

Collection of diagrams, models, &c. Lent by **Mr. Peter Fyfe,** Sanitary Inspector, Glasgow.

THE INTERNATIONAL

Smoke Abatement Exhibition

(Under the direct Auspices and with the co-operation of the Coal Smoke Abatement Society.)

Royal Agricultural Hall, London, March 23 to April 4, 1912.

Special Notice.

The Exhibition Management are not in any way responsible for the statements made in connection with the Exhibits, the descriptions of which have been supplied by the various Exhibitors.

List of Exhibitors.

VISITORS' NOTES.

Stand Nos. 1 & 2.

Western Valley's Anthracite Co.,
Swansea.

Samples of Smokeless Fuel.

Stand No. 3.

J. Shannon,
Shannon Engineering Co.,
22-24, Maidenhead Court,
Aldersgate Street, E.C.

Hammond Water Heater.

A new water heater which has been recently placed upon the market is shown on this Stand for the first time at any Exhibition. The apparatus has been reported on by Mr. Nandy Haskins, the well-known consulting sanitary engineer and surveyor, who, after having had it under observation for about six weeks, states that he considers the "Hammond" to be "the best heater on the market. There is complete combustion of the gas, and therefore a greater heat, and no contamination of the air."

Stand No. 4.

Bilbie, Hobson & Co.,
Engineers,
106, Queen Victoria Street, London, E.C.

Gas Engines.

A most interesting display is made on this Stand, the following being the principal features :

Visitors' Notes.

One Hornsby Stockport Gas Engine of latest design, fitted with magneto electric ignition, special arrangement of valves, equal to $2\frac{1}{4}$ brake horse power with Town's Gas.

One Hornsby Stockport Gas Engine of latest design, fitted with magneto electric ignition, special arrangement of valves, equal to 11 brake horse power with Town's Gas.

The Stand is illuminated by 100 candle power High Pressure Gas Burners (Marsh & Thorp system).

Patent Marsh & Thorp Combined Blower and Governor, with by-pass arrangement suitable to pass 100 cubic feet of gas per hour, for high pressure lighting and other purposes.

One Marsh & Thorp's Combined Anti-Pulsator and Governor to prevent pulsation of gas in mains and suitable for gas engine of 10 horse power.

Several samples of Marsh & Thorp's Burner Testers.

Stand No. 5.

Underfeed Smokeless Fire Syndicate,

24, Palace Gardens, Westminster, S.W.

A Smokeless Fire Grate.

On this Stand visitors have an opportunity of seeing the manner in which underfeeding may be applied in the case of either closed or open fires. The inventor of this smokeless fire grate, Mr. Thomas Bowden, claims that it is a practical solution of a difficulty which has been exercising the minds of scientific experts for the past 300 years. The advantages claimed for the grate are that it is extremely simple in action in that fuel may be added to the fire, when once lit, with as little trouble as in the ordinary way, with the exception that it is fed at the base of the grate instead of being thrown on the top of the fire, resulting in a smaller consumption of fuel—a very great consideration with coal standing at 40/- per ton.

These grades are suitable for domestic use, kitchen ranges, steam boilers, stoves, &c. On this Stand, there is also exhibited various appliances for economising fuel, consuming smoke, minimising soot, dust and ashes.

Stand Nos. 6, 7 & 8.

Carron Company,

Carron Warehouse, 15, Upper Thames Street, London, E.C.

An Electric Range.

The feature of the Stand occupied by The Carron Company, 15, Upper Thames Street, E.C., is an Electric Range, with which they demonstrate how effectually cooking of all kinds can be done with electric heat. On this Stand they also show high class Sheffield made goods suitable for Garden City property, besides a number of specialities for use in hotels, public institutions, etc.

Stand No. 9.

The Eagle Range & Gas Store Co., Ltd.

127, Regent Street, London, W., & 58, St. Paul's Churchyard, London, E.C.

The Exhibits on this Stand comprise the following:—

In operation—The "Premier" Gold Medal Eagle Range, including the following additional recently patented improvements: Hinged fire-front for cleaning fire-box and boiler flue. Improved movable bottom grate, raised or lowered with one hand. The fire-box is fitted with iron smoke consumers. Improved reversing damper (the heat can be directed entirely to bottom or top of oven as desired). Foot openers for oven doors. These smoke-consuming cheeks are made of a specially-tough iron, and have a series of gills or heat collectors cast on the back. These cheeks are placed on each side of the fire, and (when no bath boiler is used) at the back also; the front part of the cheeks and gills get very hot, a supply of air is admitted at the bottom of the cheek, which, coming in contact with these gills, is heated to a very high temperature, and come out in jets through small holes at the top. The effects of these jets of superheated air playing directly on the smoke, as it passes off from the fire box, is to cause most of the smoke and gas to burst into a flame, the ovens and hot-plate heat much more quickly, and with much less fuel, and the deposit of soot in the flues is very small. As only the thin outer rim of the consumer is in contact with the iron of the Range, there is little or no loss of heat by the conduction, as the heat conducted through

Visitors' Notes.

the front of the cheek is returned into the flue through the jets at the top. Improved indicating dampers, showing plainly on the front exactly at what draught the range is working. Improved hot closet canopy and draught regulator; keeps joints, etc., hot, ventilates the kitchen, and automatically regulates the draught of range. Perfect ventilation of oven. All flues (including boiler flue) complete in the range. The boiler can be fixed or removed from the front without dismantling or removing the range. Increased depth of hot plate, while reducing required depth of opening for fixing.

The "New Portable" Eagle Range, fitted with oven and side boiler, or H.P. bath boiler of improved patterns. Many other improvements are contained in this range.

In operation—The Eagle "Imperial" Grate. With adjustable front bars and smoke consuming back brick.

Also the Gold Medal Eagle "Premier" Grate.

Also the Eagle "Governor" Grate, containing many of the advantages of the "Premier," but produced at a price slightly in excess of the ordinary register.

The Eagle Chimney Cowl, for prevention of down-blow.

The Eagle Independent Hot-water Boiler and Hot Closet.

Stand No. 10.

McDowall, Steven & Co., Ltd.,

Ironfounders, St. Andrew's Wharf,

4, Upper Thames Street, E.C.

Patent Ranges and Fires.

This firm exhibit their "Lion" patent Ranges and Whiteflame Fires.

The "Lion" Range possesses several new features which combine to render it one of the most perfect and fuel economising cooking ranges on the market. The fire box is designed with a special view to ensure economy in burning, while at the same time the new design of boiler and boiler flue, provides for an abundant supply of hot water for baths.

The boiler flue cannot become choked with cinders and coal deposits—a frequent cause of failures of hot water supply—which fall into the chamber under the boiler, where they can be removed and sifted at any time.

VISITORS' NOTES.

The "Lion" Range is fitted with patent soot-receiving shelves under the ovens to ensure the complete removal of soot—this arrangement enables the flues to be simply and thoroughly cleaned. The oven door is fitted with an inner glass door which renders opening the oven door unnecessary during progress of cooking thus preventing ingress of cold air into oven. Further the oven doors are fitted with improved foot pedal releases, thus allowing the cook the free use of both hands—and heat indicators of a new design have been introduced on oven doors.

The oven and boiler flues are formed in cast iron, so that the satisfactory working of the range is assured.

The "Lion" Range shown in operation so that its features and characteristics can be studied during the actual progress of working.

The Whiteflame Patent Fire is an entirely new type of fire on the underfeed principle.

In it the coal is partly digasified before reaching the fire well and the gases evolved are burned more completely and to better purpose than is usually done in open fire grates.

The construction of the Whiteflame fire provides that the coal gases having no outlet except through the glowing coal, are thoroughly consumed, passing as a sheet of flame up the face of the back brick. The red hot surface of the coal is always uppermost and to the front, also as the fire is fed from behind and below, it is not blanketted with shovelfuls of black coal, so a bright fire is always maintained.

The Whiteflame fire can be allowed to go almost out, because when a little fuel is drawn from the chamber at back on to the fire it immediately bursts into flame, and in a few minutes a cheerful fire is obtained.

As in the case of the "Lion" Range there is a Whiteflame fire in operation from which visitors will be enabled to see to what an important extent this type of open fire will lessen the domestic smoke nuisance and provide a healthy atmosphere inside as well as outside the dwelling, while at the same time retaining all the advantages of an open fire over the closed type of stove as a natural ventilator to the room.

Stand No. 11.

Premier Tarless Fuels, Ltd.,

91-93, Bishopsgate, London, E.C.

Tarless Fuel.

For domestic use, Tarless Fuel which is shown on this Stand, is, it is said, superior to coal because it is cleaner in use than coal, is lighter to handle, and reduces the fuel bill. Even

Visitors' Notes.

with bad draught from poor chimneys it burns well. No special grates or other fittings are needed to consume it. Tarless Fuel is entirely smokeless and produces no soot. Neither does it set free sulphurous gases. Thus it is much cleaner in burning than coal and does not damage picture frames, curtains, carpets, or hangings. With the present unfortunate trouble in the coal world this will prove very interesting to visitors who will not omit to note that although Tarless Fuel does not contain a greater number of heat units than coal, its practical efficiency for domestic heating purposes is greater, the larger proportion of its calorific value, converted into sensible heat, being radiated into the room.

Stand No. 12.

James Stott & Co.,

158, Queen Victoria Street, London, E.C.

The Stott Gas Governor.

The "Stott" Mercurial Gas Governor as supplied to H.M. Home and Colonial Governments, and which has already been awarded over 100 prize medals is shown on this Stand. Another interesting exhibit is "Stotts" Patent Gas Kettle or Water Boiler for the supply of boiling water, the only kettle from which water cannot be drawn until it boils. The water flows the full bore of the draw-off, and can be drawn direct into a cup without fear of scalding, and thus prove very adaptable for use in Restaurants, Cafes, Hotels and Clubs.

Stand No. 13.

Coalexld, Limited,

Lancaster.

A Smokeless Fuel.

The Exhibit by the above Company comprises Coalexld burning in an ordinary sitting room range and in an anthracite stove.

For the information of visitors we may say that Coalexld is a patented process in which the application of chemicals to coal charged in a gas retort and bye-product oven, so changes gas coke that it burns freely and smokeless. The adoption of the process involves no extra expenditure for plant or labour. Besides improving the coke, the process also improves the quality of the gas and bye-products. This fuel is being largely used for steam raising, motor lorries, in suction gas plants, and for domestic use, both in the sitting room range and ordinary kitchen ranges. It is also being used by the leading

Visitors' Notes.

hotels and restaurants and for malting purposes because of its purity as a fuel. This fuel can be made at any gas works or in any bye-product ovens.

Stand No. 14.

The Interoven Store Co., Ltd.,

78, Great Queen Street, Kingsway, W.C.

Interoven Stoves, Radiators and Anthracite Stoves.

Stand No. 15.

The Sinclair Iron Co., Ltd.,

Wellington, Salop.

A New Back Plate.

On Stand No. 15 this Company show the "Roseneath" interior fitted with the new patent back plate which they have recently introduced and which constitutes, it is claimed, the only Smokeless Open fire grate at present on the market. In this grate the fire glow is at an angle of about 45 degrees, with the result that nearly the whole of the heat generated in the fire basket is radiated into the apartment, the back being so constructed that the heat in the escaping gases is largely exhausted before they enter the chimney. This, of course, leads to economy and if from this point of view only, particularly when we bear in mind the current price of fuel, the new plate merits close attention.

Stand No. 15a.

N. V. Hoels Gashaardenfabrik,

Den Haag, Piet Heinstraat 64.

A Gas Hearth giving the maximum amount of warmth with a minimum consumption of gas.

Stand No. 17.

Samuel Bros.,

Ludgate Hill, London, E.C.

Rubberless Rainproof Cloth. An "Actual-Rain" demonstration of the rainproof yet porous qualities of the "Omne Tempus" (Reg.) Rubberless Rainproof Cloth. A piece of cloth is placed slantwise on to which water is continually dripping from a cistern placed above. It will be seen, however, that the water does not penetrate the cloth, and to satisfy themselves on this point spectators are requested to rub the back of the

Visitors' Notes.

cloth. The visitor is also invited to ask the assistant to blow some tobacco smoke through the cloth in order to prove that although the cloth is absolutely waterproof, it is at the same time porous, and will, consequently, admit air.

The following guarantee is given with every "Omne Tempus" garment:—

"If your "Omne Tempus" fails to keep out the rain we will take it back."

"Omne Tempus" is the only Rubberless material guaranteed to keep out the rain.

Slip-Ons, Suits, Riding Breeches, Hats, Caps, Leggings, made of "Omne Tempus" material.

Stand No. 19.

William Wittaker,

Yorkshire Street, Iron Works, Burnley.

Coking Stokers.

The special features of the Coking Stokers which is exhibited here are the two rams for each flue (Lancashire Boilers) working alternately, with a coal regulation for each ram. These rams work at an incline of 15 degrees, in order to prevent coal dust from coming back on the return stroke. It is a simple reciprocating motion, having fewer working parts than other makes. All the reduction gears are machine-cut and enclosed in oil and dust proof covers. The coking plate is made on an entirely new principle, being inclined instead of placed in an horizontal position, thus causing the coal to ignite more quickly, which is absolutely essential for a Coking Stoker. The middle portion of the coking plate is hinged, and can be dropped in an horizontal position, so that hand-firing can be resorted to when starting up. The coking plate has a number of air spaces running through its length, and the air for the coking process is entirely independent and separate from that of the fuel combustion process. The furnace is built on an entirely new principle, having a number of fire bars mounted on the stock of steel tees, and which when placed side by side, form a closed air chamber, the air to same being supplied in an approved manner. Owing to the method of construction, the furnace is considerably lighter and very much stronger than other furnaces made wholly of cast iron. The grate is absolutely self-cleaning, all clinker being deposited into a closed chamber at the back of the bars, and is withdrawn underneath the grate by a special shovel at intervals. The speed of this action can be varied in accordance with the quantity and quality of the coal to be consumed. The bars are driven by cams on a transverse hexagon

Visitors' Notes.

steel shaft, and all the wearing parts are provided with renewable hardened cast steel pieces, thus ensuring a long life, simple and cheap renewals. Provision is made so that whatever small ash falls through the air spaces of the fire bars, is automatically discharged through the bottom of the steel tees. Absolute smokelessness is obtained and no smuts or grits are emitted from the chimney. The material and workmanship is of a very high order.

On the same Stand a Special Sprinkler Stoker is shown, in which the special features are as follows :—Two revolving shovels for each flue (Lancashire Boiler) with a coal regulation for each shovel. Simple rotating motion having few working parts. Small or slack coal is evenly distributed on about three-fourths of the length of the grate, the self-cleaning action of the bars carrying the forward. The fuel is scattered on only one side of the grate at a time, *i.e.*, alternate side firing, this method of firing is a very important factor in preventing the emission of smoke. The coal regulator will supply more fuel to the fire than it is possible for any draught to consume, or as much as may be required to suit the varying conditions.

Stand No. 20.

Babcock & Wilcox, Ltd.,

Oriel House, Farringdon St., London, E.C.

A Chain Grate Stoker.

This well-known firm devote a considerable portion of their Stand to the exhibition of one of their Patent Chain Grate Stokers of which there are over 5,200 in use and which are specially designed for the efficient and smokeless combustion of semi-bituminous fuel. The grate consists of an endless chain of short interlocking cast-iron grate bars, linked together, running on rollers, and driven by a revolving drum at the front end of the stoker ; the necessary power being transmitted through a link chain and sprocket wheels, from a shaft arranged either overhead or underground.

The starting or stopping of the stoker, or the variation of speed, is effected through the Babcock & Wilcox Patent Gear Box, which provides for varying speeds.

The coal is fed over the whole width of the grate, the depth of the fire being regulated by the adjustment of the vertically lifting fire door. The feed of the coal is slow, and the gases evolved from the fresh fuel pass underneath a highly-heated fire-brick arch, and over the incandescent coal, and complete their combustion before

Visitors' Notes.

con... with the boiler-heating s...

...gradually consumed as the grate ..., when the dumping bars are ... ash and clinker remain, which fall ... receiving pit provided with a hinged bottom ... opened as and when required to allow ... clinker being removed.

The depth of the fuel and the speed of the grate can be adjusted in a minute to suit the conditions of draught available, the class of coal to be burned, and the evaporation required.

In case of need the stoker can also be worked by hand, by means of a crank placed on the end of the worm shaft. Should the working of the stoker from any cause be temporarily affected, hand firing may be resorted to.

In addition, Messrs. Babcock & Wilcox will also exhibit models of their well-known safe, efficient and durable land and marine type water-tube boilers and boiler parts.

Stand No. 21.

Jelly & Co.,

Oxford Street, Leicester.

Ventilators and Dust Extractors.

A very interesting exhibit is made by this firm of ventilating engineers, who show a complete range of Exhausting Fans, with all latest improvements, single and duplex, belt and electrically driven, suitable for exhausting deleterious dust, smoke fumes, etc., from workrooms, casting shops, grinding and polishing wheels as used in the metal trades, etc. These may be adapted also for wood working machinery, cloth factories, lead works. At this Stand a specimen plant is in operation, showing the complete extraction and collection of dust, at considerable reduction of power.

Here also there is shown a new type of Ventilating Fan, for removing vitiated air from workrooms, offices, etc. Another most interesting item consists of Blowing Fans for cupolas, forges, brazing hearths, etc. Visitors will also be introduced to new methods of cooling liquids, hot rooms, and the absorption of moisture; drying of fabrics and timber.

Messrs. Jelly & Co., in addition, exhibit various types of Ventilators for factory and other buildings, together with the "Coxhead" and "Whirlwind" Smoke Cure," which is claimed to ... most e... in preventing down draught in chimne...

Visitors' Notes.

Stand No. 22.

Crosthwaite Fire Bar Syndicate, Ltd.,

**278, Birkbeck Bank Chambers,
High Holborn, W.C.**

The Crosthwaite Patent Furnace as applied to Boilers of the Lancashire, Galloway, Marine, Dry Back Marine and Water Tube types, with indestructable furnace bars and smoke consuming bridge bars.

Bars of various pattern showing the Crosthwaite system of air cooling, and admission of secondary air for ensuring smokeless combustion. were also exhibited

Stand No. 23.

Compagnie Francaise des Brevets Schaller, Paris,

Agents—Leif Sundt & Co., 101, Leadenhall Street, London, E.C.

A Coal Saver.

This Paris house show the "Smokeless" Coal Saver and Smoke Consuming Apparatus manufactured by them. This apparatus, which is fully patented in all countries, can be readily fitted to any furnace, boiler, grate, stove or range, and seeing that this is the first time the apparatus has been exhibited in England, it is entitled to very general attention."

Stand No. 25.

Fraser & Chalmers,

3, London Wall Buildings, London, E.C., and Erith.

The exhibit on this stand consists of a large coloured canvas screen 10 ft. × 6 ft. showing a general sectional arrangement of a Bettington boiler for pulverized fuel; also photographs of the various manufactures, and complete catalogues of all machinery made by the firm.

Stand No. 27.

The Treibel Smoke Combustion Company, Limited.

65, Bishopsgate, London, E.C.

The patent furnaces exhibited on this stand will appeal to boiler owners on account of their simplicity and solidity of construction, and the ease with which they can be applied to almost any type of boiler, old or new.

Editors' Notes.

The absence of all mechanism ensures immunity from breakdown, and consequently the repair bill is actually nil.

There are no steam jets, which waste steam, and sometimes even endanger the life and limbs of the firemen. The action of the furnace is entirely automatic, and requires no attention from the fireman.

The complete abatement of smoke nuisance together with the large economy (varying with circumstances) is guaranteed.

Ask for a free trial.

Stand Nos. 28 & 55.

Ozonair, Ltd.,

96, Victoria Street, London, S.W.

The Use of Ozone.

On this Stand there is shown a selection of Ozonair apparatus, used in the production of absolutely pure ozone. Ozone, owing to its adoption on the Central London Railway and in many important public buildings, has come to be generally known as a great aid to ventilation, purifying and freshening the air in living rooms, offices, shops, theatres, hospitals, etc., by destroying the organic matter, smoke, fog, and other things which tend to contamination.

Ozone is also employed for the purification and sterilisation of drinking water supplies whilst its industrial applications are very numerous. Amongst some of these may be mentioned the preservation of food for long periods, for helping the brewer to improve his yeast and prevent contamination in his beer; and for bleaching and purifying fats, waxes, etc. Ozone is now also being employed in various Therapeutical applications, and is a necessity for consumptive patients who have to reside in towns, instead of in the open air of the country.

The apparatus exhibited includes examples of the principle portable types of Ozone Generators made by the Company. An important feature of the apparatus is that in producing ozone no nitrous oxides are formed and consequently there is no liability to harmful effects. Small portable machines, suitable for use in the home or the office, which can readily be carried round from room to room as required, are also shown. Similar machines more especially adapted for fixing permanently on to a wall, ceiling, etc., these are intended for use in lavatories, passages, small refrigerating stores, etc. Larger apparatus designed for use in public halls, factories, schools, shops, markets, etc., is also on view.

VISITORS' NOTES.

Stand No. 30.

Carl Zeiss, Ltd.,

13-14, Great Castle Street, Oxford Circus, W.

New Zeiss Gas & Water Interferometer.

The exhibit on this stand consists of a New Zeiss Gas and Water Interferometer for technical analysis of gases and water by the interferometrical method.

This interferometer is of greatest convenience in use, being portable, same can be taken anywhere for testing gases in mines, etc., or can be arranged for water tests and is quite a unique instrument.

The portable gas interferometer is of an upright cylinder pattern of about 10 cm. diameter, and 50 cm. lengths, the only part, which is detached, being a small accumulator.

With gas chambers 10 cm. long, it reads percentages of CO_2 and CH_4 with a degree of accuracy within 0.01 to 0.02 per cent.

The weight of the portable pattern is about 11 lbs. Demonstrations will be given daily at certain intervals.

Stand No. 31.

The Power Gas Corporation, Ltd.,

Stockton-on-Tees.

Mond Gas.

The Corporation specialises in the generation of Gas for power and heating purposes from ordinary cheap bituminous coal, peat, lignite, brown coal, colliery refuse, wood and other fuels, with or without the recovery of sulphate of ammonia and other bye-products, and in the manufacture of plant as used in such processes. Here they exhibit a Model of a Mond Gas Plant, to gasify 100 tons of coal per day of 24 hours, complete with sulphate of ammonia and tar recovery apparatus.

They also show photographs illustrating various sizes of Mond Gas Producer Power and Heating Installations, both with and without ammonia recovery apparatus, together with samples of Sulphate of Ammonia from coal and from peat.

Stand Nos. 32 & 51.

The Smoke Consuming Co., Ltd.,

29, Morville Street, Birmingham.

Smoke Preventers.

This Company show Thomas's Patent Apparatus for the prevention of smoke from factory chimneys. The appliance can be fitted to

Visitors' Notes.

Visitors' Notes.

practically all boilers without altering any of the existing fittings. The furnace front and bridge is removed and replaced by others which comprise the invention, the original means of attachment being used.

The special features of the invention consist in a fire door fitted with a movable grid for admitting air above the bars, and a damper below the bars, at the end of the furnace with a directing baffle beyond. The invention is put into operation as follows:—When the furnace door is opened for feeding coal into the furnace, a piston in a dash pot containing oil attached to the furnace front is automatically forced downwards against a spiral spring and the oil freely passes from the bottom to the top of the piston. The movement of the piston in the dash pot is communicated by a cord or chain to the grid in the fire door and the damper at the back of the furnace, so that when the fire door is opened both these inlets for air to the furnace are opened too. When the door is closed the grid and damper close by their own weight and the rate of closing is retarded by the action of the dash pot to which they are attached, and which is fitted with a special regulating device. By this means, not only can the quantity of air admitted over the bars and at the back of the bridge be exactly regulated, but the rate of inflow diminishes gradually as the process of combustion proceeds. The air passing through the fire door mixes with the smoke rising from the green coal and this again meets a further supply of air coming from the damper below the bars, which has the result of causing the whole of the smoke generated to burst into flame as it passes over the bridge, so that the boiler furnace is filled with a burning gas instead of smoke.

The advantages are said to be two-fold, namely, that there is no smoke passing into the flues and stack and on to pollute the air outside, and also that a saving of from 10 per cent. to 30 per cent. is obtained through perfect combustion of fuel.

The whole of the mechanism is quite simple in its action, and being automatic requires no attention whatever from the fireman. It is also simple in construction and neither liable to wear and tear or to get out of order.

Stand Nos. 33 & 50.

Haughton's Patent Metallic Packing Co., Ltd.,

20, St. Mary-at-Hill, London, E.C.

Metallic Packing, Etc.

On this stand are shown specimens of Haughton's engineering fittings for gas works

and chemical works, comprising the following :— Fittings and parts of plant for use in connection with corrosive gases and fumes, acid gases and acids at chemical works, sulphuric acid works, superphosphate works, also various parts and fittings for use on vitriol chambers.

Gas works fittings, comprising ammoniacal liquor cocks and valves, sulphate of ammonia plant fittings, acid connections, liquor elevators. Heavy iron gland cocks and valves for gas works use, also fittings for tar works and connections for tar stills. Various forms of acid resisting iron fittings are shown, suitable for use with nitrous fumes and nitric acid, in connection with explosive works; together with samples of acid resisting iron for use under various conditions with corrosives at chemical works, gas works, and explosive works.

Specimens of water atomisers for the absorption of corrosive fumes and gases, either for use in vitriol chambers or for laying dust, smoke, and absorbing noxious fumes in various industries are shown. The stand also contains specimens of the Haughton's Patent Metallic Packing, comprising the packing in its loose form as supplied; also specimens of the packing in its compressed form this being suitable fcr use in engines, pumps, acid pumps, pumps for ammoniacal liquors and gas works use. Here also may be seen centrifugal pumps for pumping large quantities of sulphuric or sulphurous acids in chemical industries.

Stand Nos. 35 & 48.

Edward Bennis & Co., Ltd.,

Little Hulton, Bolton.

Interesting Boiler-House Exhibit.

The five smoke abatement exhibits on this stand constitute together a complete Smokeless Machine Stoking and Coal and Ash Handling Plant. Different methods of supplying coal to two types of mechanical stokers are demonstrated: the "Bennis" High-temperature Smokeless and Gritless Coking Stoker, fitted to an internally-flued boiler, and the "Bennis" New Patent Smokeless and Gritless Chain Grate Stoker, fitted to a water-tube boiler.

A "Bennis" Elevator, fitted with rotary feed and special chain and buckets for boiler-house use, are shown elevating the coal to bunkers composed of rivetted plates and supported on massive stanchions. Part of the bunker is provided with a hopper bottom, and fuel is fed direct from the bunker into the coking stoker. A shoot leading from the bunker feeds the chain grate

Visitors' Notes.

stoker. The fuel thus fed into the stokers travels along the bars, and after passing through the furnace is fed by a "Bennis" Gravity Bucket Conveyor, fitted with automatic tripping levers, into the boot of the elevator mentioned above. The entire process is continuous, and the plant is driven by an A.E.G. motor. Shaw mountings are fitted to the boiler fronts.

The "Bennis" High-temperature Smokeless and Gritless Coking Stoker. This machine is of the latest type, with patent air-cooled doors and cooling plates round the stoker front. This stoker and self-cleaning compressed-air furnace will burn, according to the draught, from 10 to 60 lbs. of fuel per square foot of grate per hour without smoke or grits. By its design the qualities lacking in the ordinary coking stoker—large evaporative boiler capacity, economy, and flexibility—are ensured. It is unsurpassed in the production of power and economy from the boiler, and is absolutely smokeless and gritless.

The "Bennis" Patent New Link Chain Grate Stoker. This chain grate stoker embodies all the improvements of the latest types that have hitherto been made. The links are halved together and rounded at their ends, and the drive is adapted to give six variations of speed, to suit various classes of coal and varying loads. The grate can also be used with forced draught. The provision of the patent air seals (which prevent the entry of an excess of air at the sides), the machine-cut 6-speed gear running in oil, and ball thrust bearings, are among the improvements that render this smokeless chain grate stoker the best on the market for all types of water-tube boilers. It has been installed by the Admiralty, and excellent results are being obtained in the boiler-houses of many electrical and industrial undertakings in the United Kingdom and on the Continent. It produces an absolutely smokeless and gritless fire.

A "Bennis" Automatic CO_2 Recorder and Calorimeter is also exhibited.

Stand No. 36.

The Tintometer, Ltd.,

The Colour Laboratories, Salisbury.

Scientific Instruments.

Apparatus for measuring and recording the colour and density of smoke from factory or other chimney stacks The apparatus consists of an optical instrument and a set of glass standards graded in accord with Rinjelmann's scale and corelated to the black units of the Tintometer colour scales.

Visitors' Notes.

A Fog Tester, being an instrument for determining the colour and density of fogs and for ascertaining the decrease of daylight intensities.

A Chromo-Pyrometer for associating the colour of incandescent furnaces or metals with their temperatures.

Complete range of Lovibonds' Equivalent Colour standards.

Stand No. 37.

W. T. Nicholson & Clipper Co., Ltd.,

Clipper Works, King Street, Salford.

Belt Fasteners.

This Company make a thoroughly representative display of Belt Fasteners and in addition to the original "Clipper" Belt Tools and Hooks show several new forms of Fasteners. Amongst these, visitors should note that The "Klincha" Tool and Fasteners provide a quick means of making the joint, the hooks being connected together by means of a serrated metal strip. On this stand there may also be seen Nicholson's Special Composition Wire Belt Lacing, "Drednort" Flexible Belt Fasteners and the "Klincha Cable" Belt Fasteners, the latter being a most handy Fastener for top drives. Here visitors have an opportunity of inspecting an Indestructible File or Tool Handle which prevents the splitting of handles, with the additional advantage of there being no danger of the tang of the tool running into the operator's hand. Another safety appliance is also on view in the shape of the "Klincha" Belt Shifter; an improved tool for fixing belts on pulleys without danger.

Stand Nos. 40 & 43.

Witting Bros., Ltd.,

49, Cannon Street, London, E.C.

Meguin Coal Screeners and Washers.

This firm who act as sole agents in Great Britain for H. Méguin & Co., A–G., Dillingen Saar, show a Model of a Méguin Coal Screening and Washing Plant. This very interesting model represents a head-gear, the shaft building, a screening and loading plant, and the coal washery, with the necessary bridge connections. The head-gear is arranged for two cages, each working independently of the other. The cages have two decks each. The coal tubs, which are withdrawn at the lower pit bank, are aised by means of the auxiliary hoist to the main

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platform, where all coal tubs come together. There are four tipplers on the tippler platform, used for tipping the coal on to the swing screens. The latter are so arranged that by closing the flap under the screen bottom either the whole of the pit coal, or, if this flap is opened, the screened large coal only can be brought on to the picking belts. From the main platform a bridge branches off, by which the coal is either brought to the boiler-house or to be stored outside the washery. Corresponding to the four tipplers there are four swing screens and four picking belts. On the latter a careful picking out of the shales is afforded. The loading of the coal into railway waggons takes place over movable arms, which are lowered into trucks or raised out of them by means of an electrically-driven winch. The picked-out shales are thrown into tubs standing beside the picking belt. These tubs are raised by means of the hoist on to the tippler platform, and then brought to the waste heap. The capacity of this colliery plant amounts up to 5,000 tons per day, and the screening plant is capable of loading approximately 4,000 tons per day. The washery consists of two units, each one working independently of the other. Each unit is capable of dealing with 150 tons of coal per day. The raw coal is lifted by the feeding elevator out of the elevator pit, which is partly arranged underneath the railway lines on to a reciprocating screen, which separates the coal to be washed into fine coal 0 to $\frac{3}{8}$ in., and nut coal $\frac{3}{8}$ to 3 ins. The fine coal, 0 to $\frac{3}{8}$ in., is freed of its dust before washing, by means of a circulating air current. The dust settles in a tank below, and is conveyed, by means of an elevator and band, either into separate pockets or into the washed fine coal. The fine coal, when freed of its dust, is carried by means of water to the fine coal washer and washed, all the nuts after washing going on to a classifying screen arranged to separate four sizes of nut coal. The nuts when separated are also drained, and slide down the spiral shutes into the nut coal pockets. These spiral shutes prevent the nuts from being broken. When the nuts are withdrawn and loaded they again pass over screens on which they are rinsed with fresh water. The loading into railway waggons takes place over movable shutes. The washed fine coal flows into sumps, from where it is lifted by elevators having patented buckets, into coal towers passing a capacity up to 4,000 tons. The coal is withdrawn by means of slides having draining arrangements. The whole of the washery is driven electrically, partly by motors directly coupled, partly by means of intermediate shafting. The power necessary to drive the screening plant amounts to 100 h.p., while each washery unit

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requires 200 h.p., thus the total requirements of power for the screening and double washing plant amounts to 500 h.p.

Stand No. 42.

Chemical Trade Journal,

265, Strand, London, W.C.

Chemical and Technical Publishers, Consulting Chemists and Chemical Engineers.

Stand No. 45.

A. F. Davis,

2, Enfield Rd., Kingsland Rd., London, N.

Furnace Fire Bars.

This Inventor-Exhibitor is showing the patented improved Furnace Bars which bear his name. It is claimed for these bars that they can be adapted for all grates, no mechanical appliances whatever being required, and that their use leads to economy in fuel consumption with high efficicncy, resulting in the prevention of the emission of black smoke and the formation of soot on the tubes. The patent for these bars was only granted last year, and thus, being entirely new, they are sure to receive a vast amount of attention.

Stand No. 46.

J. A. John, Ltd., (Incorporated in Germany)

73 & 73a, Camden Road, London, N.W.

A Soot and Spark Catching Cowl.

What is claimed to be an effective remedy for the troublesome and injurious soot nuisance, is shown here. The apparatus is exhibited in various sizes and models, and should be of the greatest interest to every architect, builder, manufacturer, as well as to the health and sanitary authorities. Along with these novel apparatus is exhibited a full range of the John's Patent Revolving Chimney Cowls—"Squirrel," in various models and sizes. This Cowl is said to offer a most effective cure against down-draught, and while acting as a splendid ventilator it will, at the same time, improve the up-draught in the chimneys on which the Cowl is fixed.

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Stand No. 47.

Bean's Bunsen Smokeless Furnaces Co., Ltd.,

Amberley House, Norfolk Street, Strand, W.C.

This is an Exhibit worthy the attention of all steam users for the production of cheap steam with smokelessness.

The principal features may be summed up as follows :—

1. Economy of fuel guaranteed, ranging from 5 to 15 per cent. according to the efficiency and conditions under which the boiler has been working.

2. Elimination of smoke guaranteed, although the cheapest kind of soft coal is used ; this is an extremely important point to manufacturers located in cities who are frequently compelled to use Welsh Coal to avoid the smoke nuisance.

3. With Lancashire and other internally fired boilers, a striking feature of this furnace is the diminution of sedimentary deposit in the internal flues, clear of heat absorbing surfaces.

4. The furnace is of simple scientific firebrick construction, maintenance is almost a negligible factor—there is a total absence of mechanism, consequently nothing to get out of order, and it can be readily installed in Lancashire and Cornish boilers in from 12 to 20 hours.

5. The cost of installing the furnace is based on the economy in fuel effected, introducing the unassailably sound principle of payment by results.

Stand No. 52.

F. Simmett & Co.,

17, Souchiehall Street, Glasgow.

Scientific Instruments.

A fine display of scientific instruments is made on this Stand. Included in the display will be Barometers, Chemical Flasks, Porcelain Ware, Hydrometers, Thermometers, Lenses, Levels, Frames, Glass Tubes and Test Tubes.

Stand Nos. 56 & 69.

Ewart & Son, Limited,

346, 348, & 350, Euston Road, London, N.W.

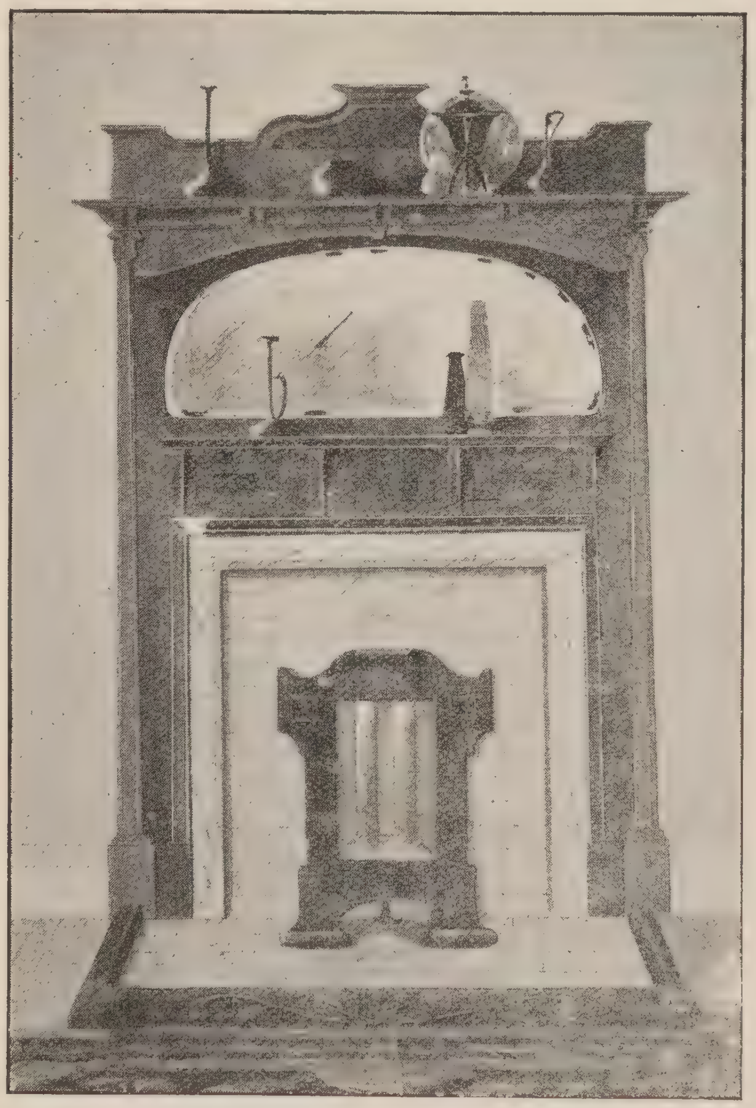
Instantaneous Water Heating.

On this Stand a large assortment of Geysers. "Califonts," and Instantaneous Water Heating Appliances heated by gas are shown in operation.

Visitors' Notes.

THE THERMAL SYNDICATE, LTD.,
WALLSEND-ON-TYNE.

PURE FUSED SILICA WARE
TRADE "VITREOSIL" MARK.



"VITREOSIL" GAS FIRE.

HEAT PROOF
HIGHLY REFRACTORY
UNTARNISHABLE
ACID PROOF

GRAND PRIX:

BRUSSELS -	1910
TURIN - -	1911

ILLUSTRATED
PRICE LISTS
ON REQUEST.

FUSED QUARTZ GOODS OF ALL DESCRIPTIONS.

London Office - 14, RED LION SQUARE, HOLBORN, W.C.

The Heaters are adaptable for supplying hot or boiling water for almost every purpose, and demonstrations are given showing how safe, convenient and economical this method of heating water is.

Starting from the small Heater producing hot water at the rate of 1 gallon per minute, Geysers of various increased heating capacities are exhibited up to a Heater having a capacity of 10 gallons per minute.

The special arrangements under which the gas is always controlled, and all risk of burning while the water may happen to be turned off, are eliminated.

As well as the ordinary automatic tap shutting down the gas when the water supply ceases, automatic valves controlled by the heat of the water are shown.

With a combination of these arrangements it is possible to heat very large quantities of water and store it if desired at the temperature required ready for immediate use, a convenience and economy which even a few months ago would have been considered almost impossible.

Stand Nos. 57 & 68.

The Thermal Syndicate, Ltd.,

Wallsend-on-Tyne.

"Vitreosil."

On this Stand the Syndicate show a variety of Pure Fused Silica (Quartz) goods of which they are the manufacturers. The material of which these goods are made possesses unique and valuable properties. It is perfectly acid and heat-proof and is quite unaffected by extreme and sudden changes of temperature, for example the material may be, whilst at red heat, suddenly plunged into cold water without suffering fracture in any way. In this connection high pressure gas light firms are taking advantage of the ware, as chimneys made of "Vitreosil" are quite unaffected by rain and cold winds when at a high temperature.

Among the chief uses for "Vitreosil," may be mentioned tubes and plates for electric heaters and cookers, pyrometer tubes, for rapid readings and high temperatures, high pressure globes for gas lighting, basins for sulphuric acid concentration and all forms of apparatus for the chemical industry.

A new use to which the material is now being put, is in connection with gas fires where silica is employed as the heat radiating medium.

Visitors' Notes.

Stand Nos. 58 & 67.

Cannon Iron Foundries, Ltd.,

Deepfield, near Bilston, Staffs.

Gas Heating Apparatus.

This Company place in a prominent position on their Stand the "Iris" Gas Fire, the former type of which pattern secured First Position of Merit at the Official Smoke Abatement Tests, carried out in London in 1906. Many other patterns are also displayed in various finishes, including a selection of effectively enamelled fires in this Company's "Vitrolustre" colour enamel. The "Oto" Fire will command attention, it being a most modern type of very pleasing artistic effect; it is made in two sizes, in all the varying qualities above referred to. Other Gas Fires shown on this Stand include the "Adam," "Elizabethan," and "New" Styles; a distinct series, embodying the features of "Vitrolustre" Enamelled Panels, which can be supplied in the varying colours according to the preference of the buyer.

Quite a variety of types of Gas Heated Radiators are shown, embodying the Company's well-known "Equator" series, also the "Meridan" single column Radiators, and their patent "Radio" pattern, cast in one piece. They also show their "Torrid" steamless pattern, with which is embodied the pleasing effect of copper reflectors when the bottom doors are open. The "Colonnade" and "Hero" Radiators are varying types of Stoves constructed on a similar principle.

In the Gas Cookers class, representative patterns, including the "County" and "Hercules" High Grade Cookers, which are extensively hired out by leading companies throughout the country, are exhibited. Also the "Trusty" and "Ophir" patterns, representing an intermediate type of Cooker, which has become very popular. And in succession the "Thrifty" and "Homely" patterns, as usually adopted for use with slot meters. In addition to these there is the "Sparta," "Shamrock," and "Bilston" patterns, together with an array of Breakfast Grillers, Boiling Burners, Gas Irons, Washing Boilers, etc., etc., of interest to all gas engineers and the general public as labour saving appliances, and of considerable utility as furthering the object of Coal Smoke Abatement.

Gas Meters are represented by samples of the Company's latest types, including their patented Improved Radius Price Changer, with extra features such as strong box, patent alarm,

Visitors' Notes.

and stop and slot, as fully described in the Company's Catalogues.

The Company also exhibit a few representative specimens of their productions in "Porceliron" sanitary ware, which are of an interesting character. It must be noted that "Porceliron" does not represent pottery, but cast-iron with a smooth, white, porcelain surface, which combines a smart, clean appearance, with strength and durability. "Porceliron" is a trade mark as applied to this class of ware.

Two very graceful patterns are those with high mirror backs, notably the "Waldorf" and "Ritz," whilst there are other patterns that commend themselves. The patterns represented are:—

The "Waldorf, Porceliron" lavatory stand, fitted with bevel plate glass mirror and tiles, and provided with bracket holders with china vases.

The "Ritz, Porceliron" lavatory stand, fitted with bevel plate glass mirror, bracket holders with china vases and tray.

"Porceliron" roll rim lavatory range with overlap joints, with self-contained overflow. The "Bromsgrove" complete with cast-iron stand with wrought-iron top rails and tie rod.

The "Brighton Proceliron" oval lavatory with fluted pedestals.

Lavatory mirror, consisting of "Porceliron" roll rim frame fitted with bevel plate glass mirror.

"Porceliron" jaw box with round corners, fitted with brass waste plug and chain.

"Reform" Saucepans. Attention is directed to the "Reform" pattern broad bottom saucepans with "Perfect" self-ventilating strainer covers, &c. The greater diameter at the bottom gives an increased heating area size for size, compared with the ordinary bellied shape, ensuring quicker boiling temperature and therefore economy in fuel.

The "Reform" pattern also gives increased cooking space and is made with rounded corners.

The Company also supply the ordinary bellied saucepans.

Stand Nos. 59 & 66.

The Woodall-Duckham Vertical Retort & Oven Construction Co., Ltd.,

Palace Chambers, Westminster, S.W.

Retorts.

The Company show a full size Bottom Ironwork of Woodall-Duckham Vertical Retort, comprising:—(1) The special device for regulating the discharge of coke, which has proved itself, after four year's working, completely satisfactory. (2) A receiving hopper, constructed to hold three

Visitors' Notes.

hours' discharge of coke, at the bottom of which is fitted a water sealed gastight door, an ingenious contrivance for preventing any possible escape of gas, while at the same time the coke is never in contact with the water.

Another most interesting exhibit on this Stand consists of a Brickwork Section of Retort, showing arrangement of flues and the construction of the Retort.

An exact model of the Woodall-Duckham Vertical Retort, showing in fullest detail the entire construction of settings and integral parts should certainly prove of great interest to engineers, as every point can be readily seen, and when seen, appreciated.

On this Stand there is also shown a model of Kerpeley Producer, illustrating a method of making producer gas from poor quality fuel. The system is continuous in working, the clinker being extracted automatically, and by its use fuels containing a very high percentage of ash can be gasified, giving a gas of good and even quality.

Stand No. 60.

The Tella Camera Co.,

68, High Holborn W.C.

Official Photographers to the Exhibition.

Stand No. 61.

Shaw-Walker, Ltd.,

33, St. Bride Street, E.C.

Filing Devices.

Makers of the well-known "Never-stick" Filing Devices.

Sectionets are finger tip office systems. Sectionets come in any arrangement desired to suit any system; small, conveniently associated filing units, they keep your records at your finger tips. Documents, correspondence, card blanks—whatever is to be kept in files is kept most convenient to your constant personal use in a sectionet, the little filing case that makes filing service a personal convenience to the busy man.

Sectionups are four drawer vertical files. Each drawer is fitted with roller bearings. No effort required to move. Never stick.

Sectionuls are the standard files of big capacity. In office use there is nothing too bulky or of too great dimensions to find in Sectionuls a capacity that will file it. There is no requirement as to diversity of filing equipment that cannot be supplied with Sectionuls.

Visitors' Notes.

Stand No. 64.

Union Electric Co., Ltd.,

Park Street, Southwark, S.E.

Shop Window Lighting.

Example of "Union" ideal shop window lighting.

Stand No. 65.

Townson & Mercer,

34, Camomile Street, London, E.C.

Chemical Apparatus.

On this Stand, Messrs. Townson & Mercer, exhibit Somervilles' Apparatus for S. & S. H. 2; "Metrogas" Nitrogen Apparatus; Hornley's Gas Analysis Apparatus; Dickinson-Gair's Gas Analysis Apparatus; Orsat's Gas Analysis Apparatus; Alundum Apparatus; Thermometers; Flash-point Apparatus, etc.

Stand No. 70 & 87.

D. Anderson & Co.,

Lighting Engineers and Contractors,

18 & 20, Farringdon Road, E.C.

Anderson's "Dacolight" Improved 1912 Patent Arc Lamps.

The lamps Exhibited by this firm are constructed in various sizes, ranging from 40 to 3,000 candle-power, suitable either for high or low pressure gas, and may be lighted with an ordinary lighting torch or bye-pass. They can be successfully used either for public or private lighting.

Part of this Exhibition is lighted by the above lamps, low pressure gas being used.

Smith's Patent Storm Proof street lamp as used by the Liverpool Corporation, and various other types of lamps, and gas controllers for lighting and extinguishing gas lamps.

Stand Nos. 71 & 86.

R. & A. Main, Ltd.,

Gothic Works, Angel Road, Edmonton, N., & 25, Princes St., Oxford Circus, London, W.

Cooking and Heating Appliances.

For the past 40 years the name "Main" has been familiar to that progressive portion of the public which has been using gas for cooking and heating. The improvements made in the effici-

Visitors' Notes.

ency of these appliances have, of course, greatly extended their use during the last few years. In the household kitchen Main's cookers, manufactured by Messrs. R. & A. Main, Ltd., Gothic Works, Angel Road, Edmonton, London, N., and 25, Princes Street, Oxford Circus, London, W., hold a fine position, and the exhibits on their Stand include selections of the most popular of these labour lighteners.

The problem of artistic, efficient and cheap household heating appliances has received great attention during the past few years. Messrs. Main have made a special study of this problem, and their contributions towards its solution have culminated in their "D S O" and "St. Nicholas" Fires, two of the most successful series of fires ever put upon the market. The "D S O" series, in addition to their great efficiency and cheapness, are remarkable for their simple, yet beautiful design. The surfaces of these fires are perfectly smooth, and do not harbour dust. The "St. Nicholas" Fire marks an epoch, and visitors will admit that it represents a succcssful attempt to combine the handiness and cleanliness of the gas fire with the cheerful appearance of the glowing coal fire. It can be fitted into any ordinary grate with very little trouble. This fire has had a great welcome, especially from persons who object on æsthetic grounds to the ordinary type of gas fire.

Stand Nos. 72, 73, 74, 75, 82, 83, 84 & 85.

Gas Companies Joint Exhibit.

This Exhibit has been organised by The Gas Light and Coke Company, The South Metropolitan Gas Company, The Commercial Gas Company, The Brentford Gas Company, and a large number of other London and Provincial Gas Undertakings ~~to display~~ the latest, most efficient, and most economical gas appliances ~~for~~ are displayed cooking ~~the~~ heating ~~of~~ houses, flats, shops, factories, garages, work rooms, churches, hospitals, and every other public institution, hot water supply, furnace heating; and other manufacturing and industrial purposes.

The stoves, boilers, furnaces and other smokeless apparatus for use in the home, workshop, or factory, comprised in this Exhibit have been furnished by the following well-known firms of manufacturers:—

The Davis Gas Stove Co., Ltd.,
59, Queen Victoria Street, E.C.,
and Luton.

VISITORS' NOTES.

Messrs. Fletcher, Russell & Co., Ltd.,
134, Queen Victoria Street, E.C.,
and Warrington.

The Richmond Gas Stove & Meter Co., Ltd.,
132, Queen Victoria Street, E.C.,
and Warrington.

Messrs. Wilsons & Mathiesons,
Queen Street, Cheapside, E.C.,
and Leeds.

The John Wright and Eagle Range, Ltd.,
Queen Victoria Street, E.C.,
and Birmingham.

The exhibit will be found of great interest to all interested in means of abating the Smoke Nuisance, which at the same time effect economy for the user and increased comfort and convenience wherever they are adopted.

Stand Nos. 76 & 81.

The British Vacuum Cleaner Co., Ltd.,

Parsons Green Lane, London, S.W.

Vacuum Cleaners.

Believing as they do that clean flues mean less smoke and better combustion in every way, this Company bring prominently before the public their flue cleaning apparatus, and this they do in a most interesting manner. Here also the private user is enabled to inspect a two-cleaner plant of the fixed rotary type, suitable for installing in private houses, small hotels, public buildings, etc., so that the daily cleaning can be done without any disturbance of dust whatsoever. A number of small portable models are also shown here, the whole making a most interesting exhibit.

Stand Nos. 78 & 79.

James Hodgkinson (Salford), Ltd.,

Manchester.

An Automatic Coking Stoker.

The Patent Gritless and Smokeless Automatic Coking Stoker which is exhibited on these two Stands will without doubt claim a considerable amount of attention. This Stoker which is fitted with self-cleaning firebars has been specially designed for burning small bituminous fuel. On this stand Messrs. Hodgkinson submit for inspection specimens of their improved hand rocked fire-bars, for furnace and general use, these having been also designed for burning small fuel.

Visitors' Notes.

Stand No. 89.

The Metallbank & Metallurgische Gessellschaft A. G.

Frankfort, o/m, Germany.

Representative in the United Kingdom:—

Mr. H. C. Kirstein, A.M.I.C.E., M.I.M.E.,
3, Lombard Street, London, E.C.

A Smoke Dissipator.

A most interesting Exhibit is that made by the above Company who show their Patent Smoke-Dilutor or "Dissipator." This apparatus, invented by Professor Dr. Wislicenus, is self-acting without the use of any mechanical or chemical agencies, nor does it require attention of any kind, thus saving all working expenses. The dissipator forms the upper part of an ordinary factory chimney stack. It consists of a number of perforated bricks of special design, arranged in lines, like a grating. The total exit area of the perforations exceeds many times the exit area of the ordinary chimney.

The dissipator on top of a chimney performs dilution of the smoke or waste gases, by mixing a large quantity of air with them, thus neutralising as far as possible their detrimental effects.

The air entering the chimney through the perforations at the side, struck by the wind, causes the smoke or fumes to be whirled round in the very chimney, so that, when they escape through the perforations opposite, the smoke or fumes are already thoroughly broken up and diluted and owing to the radial direction of the perforations, they are still further dissipated in a most efficacious manner, the dissipating action increasing progressively with the distance from the stack.

Stand No. 90.

Direct Gas Fuel, Ltd.,

17, Victoria Street, London, S.W.

Oil and Coal.

The "Gregory Smoke Preventing and Fuel Saving Apparatus," which not only effectually prevents smoke, but by using a small percentage of fuel oil in combination with coal, obtains more perfect combustion and enables lower grades of coal to be burnt with as good results as the best qualities, ~~is exhibited on this Stand~~. This apparatus by increasing the draught has proved itself a quick and efficient steam raiser.

Visitors' Notes.

Stand Nos. 91 & 101.

John Ruscoe & Co., Ltd.,

Albion Works, Hyde, Manchester.

Steam without Smoke.

How to generate the maximum amount of steam out of boilers to the best advantage and without the emission of dense black smoke is shown by Messrs. John Ruscoe & Co., Ltd., on this Stand, where they Exhibit a "Tuto" Mechanical Stoker and Elevator, worked by one of their own make of gas engines. This question of the production of steam without smoke has been the cause of a lot of worry and anxiety at some time or other to almost all power station engineers and steam users generally, but may now, it is claimed, be overcome by the use of the appliances devised by Messrs. Ruscoe. The "Auto" is simple in construction, is efficient and economical in use, whilst the makers guarantee a higher percentage of $C.O^2$ out of the flue gases than are obtained by even the most expert hand firing or other mechanical stokers.

Messrs. Ruscoe & Co., also exhibit a case of small tools together with valves, clips, and their well-known 30 inch under-pressure drilling apparatus.

Stand No. 92.

Foster Engineering Co., Ltd.,

Morden Road, Wimbledon.

Gas Economisers.

If the best results are to be obtained from gas mantles and other apparatus, it is essential that the gas be supplied at "correct" pressure. And this it is that the Gas Governor which constitutes the principal feature of the Exhibit on this stand secures. Without the aid of such a governor this "correct" pressure is not always practicable owing to the fact that the main pressure varies within the 24 hours. By the aid of the Foster Governor this pressure is reduced to the correct level, the result being not only a great saving in gas consumpton, but also a decided improvement in the light by gas mantles and plain jets, and in the heating effect obtained from gas fires, stoves, etc.

Visitors' Notes.

Stand No. 93.

Thomas Potterton,

Engineer-Patentee,

Cavendish Works, Ravenswood Road, Balham, London, S.W.

Modern Gas Cooking and Water Heating Appliances.

This Exhibit includes all types of "Victor" boilers and accessories, together with the "Victor" complete automatic gas heated hot water supply apparatus, etc., in various forms demonstrating the utility of gas in supplying hot water for general uses.

Working example of gas fired heating apparatus for small greenhouses, conservatories, motor garages, etc.

Warming apparatus for all types of buildings heated by boilers using smokeless fuel.

The New "Seal"ed Oven Cooker. A cooker embodying all the advantages claimed for electricity and at less cost for cooking. Low gas consumption—minimum wastage of food cooked—saving upon ordinary system.

Stand Nos. 104, 105 & 106.

O'Brien Thomas & CO.,

Effingham Works, Rotherham, Yorks.

The Lasco Patent Domestic Boiler.

Amongst the novelties shown on this stand is the Lasco Patent Domestic Boiler for hot water supply to bath and lavatory basin. The advantages claimed for this Boiler are that being constructed of copper it will heat very rapidly; the waste gases of the fire being utilised in heating the boiler. This well-known firm also make a brave display of Anthracite and Domestic Stoves, and D. O. Boyd's Hygiastic ventilating stoves and grates for Schools, Hospitals and Infirmaries.

Stand No. 106a.

George J. Hutchings,

116, Blackfriars Road, S.E.

Well-bottom Cookers.

On this Stand, Mr. Hutchings shows his new patent well-bottom cookers, the principal feature of which, is that each food container has a well sunk bottom, over this is supported a removable convex false bottom, the condensed steam flows

Visitors' Notes.

into the well below, preventing the food becoming sodden with water.

On coal range, gas or oil stove, five articles of food may be cooked without mixing flavours.

One or more cookers may be used at one time without attention.

When cooking is finished there is hot water in the boiler for washing up.

Stand No. 106b.

Messrs. C. E. Podmore & Co.,

Gas Lighting Engineers and Patentees,
34, Charles Street, Hatton Garden,
London, E.C.

Gas Lighting Engineers.

Makers of high-power lamps for interior and exterior lighting—specialists in school lighting, etc. Contractors to H.M. Goverment.

Patentees of the dust-proof Bunsen burner lamp for tropical climates.

Manufacturers of street lanterns for all climates.

Stand No. 106c.

Leyton Timber Co.,

High Road, Leyton.

Stand No. 106d.

H. Kowitzke & Co.,

Berlin S. 59, Urbanstrasse 104.

London Agent:—R. H. Haylock,
63, Queen Victoria Street, E.C.

Smoke Consuming Apparatus.

A smoke consuming boiler furnace.

Stand No. 107.

The British Coalite Co., Ltd.,

3, London Wall Buildings, London, E.C.

Coalite.

A smokeless fuel which ignites readily and ensures clear flues, constitutes the salient features of the exhibit made on this Stand. Coalite, it should be noted, burns with a steady, cheerful glow, is more economical and radiates much more heat than coal. Seeing that Coalite deposits no particle of soot, it has not yet made many friends amongst the chimney sweeping fraternity, but,

Visitors' Notes.

Visitors' Notes.

on the other hand, domestic servants welcome it, owing to the absence of smoke emission or deposit of dirt in the room, whilst the uniform heat maintained in the kitchener is a source of much satisfaction to the cook.

Stand No. 109.

London Warming & Ventilating Co., Ltd.,

20, Newman Street, London, E.C.

Anthracite Stoves.

The exhibit of this well-known firm deals with the most up-to-date methods of warming every class of building by Anthracite Smokeless Coal, consisting as it does in great part of their Anthracite Continuous Burning Stoves, of which they have a large assortment on view. Other novelties include a later invention — the "Florence" Patent Boiler Grate, an open fire in which the Exhibitors burn Anthracite, and warm several radiators by low pressure hot water, as an example of how easily several rooms may be warmed from one open fire at small cost of maintenance.

In addition, the Company also show a Continuous Burning Kitchener of absolutely new type, with enclosed Mica front, which will heat the contents of a 40 gallon hot water cylinder boiling on the hot plate, cooking in oven being done before the surplus heat passes into chimney. This range is quite independent in form, and merely requires connecting to the chimney with a length of flue pipe, and is certain to prove of great interest to all well wishers of Smoke Abatement, as it is by this means possible to entirely do away with the use of bituminous fuel. Demonstrations of the cooking powers of the "Every-ready" are given at intervals daily.

Stand No. 110.

Hjalmar Lofquist,

Berger Jarlsgatan 21, Stockholm.

Electric Heating Apparatus.

Electric automatic waterheating apparatus for heating water on the Swedish system as invented by Mr. Hjalmar Lofquist, Stockholm, is shown by the inventor in operation in connection with a bath and will be found to be of the utmost interest. The apparatus is made in two sizes—$4\frac{1}{2}$ units 200 volts and 4 units for 220 volts. $4\frac{1}{2}$ units will raise the temperature of 40 gallon—181 liter water in a bath 27° Fahrenheit in 40 minutes.

Stand No. 110a.

M. Russfang Compagnie,

Hanover, Freystagstrasse 14.

Smoke Collectors.

Two automatic smoke collectors and one smoke divider in operation on the roof, and one soot collector, and one smoke divider in the Show Room.

Stand No. 112.

J. Marse & Co., Ltd.,

45 & 46, Imperial Buildings,
Ludgate Circus, London, E.C.

Incandescent Gas Burners.

Series of "Visso-Marse" burners ranging from ½ to 8 feet per hour, and from 16 to 250 c.p.

These burners are cut from a solid bar of brass and are designed in such a way that they give the highest flame temperature obtained up to now with gas burners, i.e., 1590°.

The mantles which are of a special shape, are incandescent right up to the top.

Over 3,000,000 of these burners are in use; they obtained a gold medal at the Brussels Exhibition, 1910.

Here also, there may be seen the two popular types of "Astrona" upright burners, and a new type of "Visso-Marse" inverted.

An incinerating machine of their own design for burning off silk mantles already so largely used on the Continent.

Stand Nos. 113, 114 & 115.

Falkirk Iron Co.,

Craven House, Kingsway, London, W.C.

Heating and Cooking Apparatus.

One of the most representative displays in the Exhibition will be that made by this Company who show their new patent "George" range, which they claim reaches the highest point yet attained in the evolution of the ideal cooker. It embodies many features,peculiarly its own, as visitors will be enabled to judge, the range being shown in operation. Another heating apparatus which is shown in operation for the first time at this Exhibition is the "Barker's" patent generator, linked up to radiators, demonstrating how several rooms may be heated from one anthracite fire which will burn equally well as a close or open fire. The Falkirk Company also make a feature of their well known "Era" anthracite stoves and of a new type of warm air grate which will, without doubt, prove of special

Visitors' Notes.

interest to those concerned in the proper heating and ventilating of schools, hospitals, etc.

On this Stand visitors are enabled to examine examples of the "Pelham" fire (one in use). This grate is a high class article giving great heating power and perfect combustion.

A distinct novelty is exhibited on this Stand in the shape ot a new Hot Air Controlled Combustion Stove, in "Adams'" style; this is undoubtedly the latest thing in this direction yet placed upon the market, and is adaptable for use with Coal, Anthracite or Coke.

Stand No. 116.

Tilley Brothers,

53, Kingsland Road, London, N.E.

Hot Ray Gas Fire.

This firm show one of their "Hot Ray" gas fires, controlled by a patent gas governor which can be fitted to any grate. Here visitors may also inspect the Tilley High Pressure gas system for lighting and heating.

Stand No. 116a.

H. C. Slingsby,

142-146, Old Street, E.C.

Patent Trucks and Ladders.

Slingsby's patent trucks and ladders, and trucks and ladders of all kinds.

A selection of about 60, from 1,000 varieties made and catalogued.

This business comprises 12 complete lines, viz.:—

(1.) Slingsby's sliding-wheel patent trucks, known, used and endorsed in all civilised countries.

(2.) Sack Trucks, patent "Collron."

(3.) Handcarts of every description.

(4.) Portable railway material.

(5.) Carrier tricycles.

(6.) Wheelbarrows of all kinds.

(7.) Milk carriages.

(8.) Platform trucks.

(9.) Castors, roller and ball bearing.

(10.) Slingsby—steelback pattern—extension ladders.

(11.) Slingsby—steelheld extension step-ladders.

(12.) Wheels and tyres of any design, including felt, the latest and best for most purposes, and everything appertaining to trucks, ladders, steps, and the like.

Visitors' Notes.

Stand No. 118, 119 & 120.

J. & P. Hill,

Ordnance Works, Sheffield.

"Galloway-Hill" Patent Furnace.

On this Stand visitors have an opportunity of inspecting an installation of the "Galloway-Hill" Patent Furnace. The chief features of its construction will be clear, from the following particulars. Longitudinally along the Furnace between the front and back are cast iron troughs or conduits, and transversely across these conduits are placed the short fire-bars. The conduits and fire-bars are 8 or 9 ins. wide, according to the size of Furnace, and the conduits are open at the front to admit air through the bars, but are closed at the back end. The bottoms of the conduits are perforated with large holes, corresponding with holes in slide over them, which are operated by hand. These slides permit the stoker to riddle the fine ash which falls through bars effectively, from the conduits. The bars which are of special form, are placed far more closely together than usual, leaving only $\frac{3}{16}$ in. air space. The grate is continued into a patent bar bridge at the back, the bars there being specially constructed to fit the boxes which form the bridge proper. Steam nozzles or jets are placed in front of each conduit for inducing draught along it. The bars, owing to their shape and setting, are of remarkable durability. Among the advantages claimed are the increase in total water evaporation, saving in fuels, ability to use lowest grade of bituminous coal without smoke, efficiency with short chimneys, and the simplicity and cheapness of upkeep. There are other advantageous features also, for clinker does not adhere to the bars, and rubbish and refuse can be burnt as well as the smallest coal. It is applicable to all plant where fires are required.

The "Galloway-Hill" Patent Furnace is one of the most successful systems on the market for preventing smoke, and is based upon sound scientific principles. It allows the user to fire with small smoky coal of the cheapest sort. This produces gas in the furnace, but is dealt with at a very high temperature, due to the patent bar bridge. The gases are thus burned completely with a proper mixture, and smoke is prevented. The result is *smokeless combustion*, without excess of air and undue cooling of the gases. The highest efficiency is obtained because the combustion is complete. Smoke nuisance is entirely avoided, and great fuel economy is effected.

The Local Government Review,

Maxwell House, Arundel Street, Strand, W.C.

A publication dealing with matters of interest to Local Government authorities and officials.

Visitors' Notes.

No thank you!
We use gas. It makes no soot – and saves work and worry
The GAS LIGHT & COKE Company

Official Catalogue.

THE INTERNATIONAL SMOKE ABATEMENT EXHIBITION

3D

1912

March 23 ---------------- April 4

3D

ROYAL AGRICULTURAL HALL

GAS
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See the Gas Exhibit Stands No. 72-5 & 82-5.

Preliminary Prospectus.

COAL SMOKE ABATEMENT

FUEL ECONOMY

PURE AIR & CLEANER CITIES.

Smoke Abatement and Dust Prevention Exhibition

1922 1922

ROYAL AGRICULTURAL HALL, LONDON,
Monday, March 13th, to Saturday, March 18th (inclusive).

UNDER THE AUSPICES AND DIRECT CONTROL
OF THE COAL SMOKE ABATEMENT SOCIETY
AND OF
THE WORSHIPFUL COMPANY OF FANMAKERS

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SOUTHWARK, The Mayor of
STAFFORD. The Mayor of
STEPNEY, The Mayor of
STOKE NEWINGTON, The Mayor of
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Smoke Abatement and Dust Prevention Exhibition,

ROYAL AGRICULTURAL HALL, LONDON,

March 13th to 18th (inclusive) 1922.

THE last International Smoke Abatement Exhibition held in London took place in 1912, when, notwithstanding the adverse effect of a serious coal miners' strike, a conspicuous success was achieved.

The Exhibition attracted great public attention, and was so satisfactory to exhibitors that the Coal Smoke Abatement Society was requested by many representative firms to organise a further Exhibition. It was agreed to do so, but the outbreak of War and the disturbed industrial conditions which have existed since hostilities ceased necessitated the postponement of the project.

Renewed representations and assurances of strong support have now been received by the Society, and in view of the importance of demonstrating that effective means exist for overcoming the evils of all forms of atmospheric pollution, the Worshipful Company of Fanmakers have offered to extend their full and energetic support to a further display. This pledge of active assistance from members of an ancient City Guild specially interested in Ventilation and Dust Prevention, together with other guarantees of powerful backing and support, has satisfied the Coal Smoke Abatement Society that the time has now arrived when a further Exhibition might be arranged with every prospect of success.

Mr. F. W. Bridges has been invited to accept the post of Organising Manager, and has been able to secure the Royal Agricultural Hall from March 13th to 18th, 1922, the only suitable Hall and period available for such an Exhibition during the next two years.

The Exhibition will be arranged by an influential Council under the immediate direction of the Coal Smoke Abatement Society and of the Worshipful Company of Fanmakers. This Council is largely composed of the Lord Mayors and Mayors of the great manufacturing Cities of the Country, and of representatives appointed by the learned and technical Institutions and other organisations concerned with every aspect of Smoke Abatement, Dust Prevention and Ventilation. It is also fully representative of the many interested branches of industry.

The Exhibition will stimulate interest in the production, distribution and various uses of Gas, Electricity and Oil for power, heating and lighting purposes. It will also appeal to the manufacturers or purveyors of Solid Smokeless Fuels; to the makers of mechanical stokers, furnaces, boiler-fitting and other accessories designed to increase the efficiency of the boiler house and to lessen the consumption of coal. It will be of enormous practical value to the manufacturers of grates, hot air, gas and water radiators, kitcheners and other heating and cooking appliances; to the great Oil industry, which bids fair to play an important part in many functions in which bituminous coal has hitherto been predominant, and to the manufacturers of ventilating and dust preventing apparatus of all kinds. In short, it is intended that the Exhibition shall fully cover the whole field of industry and science in any way interested in the preservation of a pure and healthy atmosphere.

The nation has emerged from the greatest struggle it has ever been called upon to face with a full recognition of the imperative necessity of jealously husbanding its coal resources. Moreover, since the war terminated the increase in the cost of all kinds of coal has conclusively shown that if the country is to recove and maintain its former prosperity and supremacy every possible economy in manufacturing processes must be practised, and every means employed to protect the health and add to the efficiency of the worker. The subject of Smoke Abatement has thus entere upon a new and practical plane.

One outcome of the last Exhibition was the formation of the Atmospheric Pollution Committee, which has since passed under official control. This Committee has shown by scientific analysis and research that owing to the consumption of bituminous coal in factories and domestic hearths, the weight of the accumulated and unconsumed particles of coal, which, in the form of smoke, is cast out into the air of London and all other large towns, reaches appalling dimensions. The whole of this waste of valuable fuel and the serious injury it inflicts upon the health and vitality of town-dwellers, as well as the great damage which it occasions to property of every description, may be prevented without inflicting any hardship upon manufacturers or householders.

The loss is indeed immense. It has been calculated that **the Smoke nuisance costs London alone upwards of £4,000,000 per annum** through the damage it occasions to property. The urgent appeals for funds to repair and protect **Westminster Abbey** from the ravages of Smoke have illustrated how seriously buildings suffer from what has been well described as our barbarous methods of burning coal.

One compensating advantage of the recent disastrous **Coal Stoppage** which had a paralysing effect upon industry, was that for the first time within living memory Londoners and others who have hitherto lived in an atmosphere of smoke, fog and dirt, were able to realise that the air of cities becomes clear as soon as the use of bituminous coal is abandoned The Nation has indeed been provided with a notable object lesson of what may be expected when Smoke Prevention is made compulsory in this country as it already is in New York.

Since the last Exhibition took place the Government has appointed a Committee to report upon Smoke Abatement and Noxious Vapours. The interim Report of this Committee, over which Lord Newton presides, has been of great value to those who are dealing with the problems of smokeless methods of heating and cooking; and it is confidently expected that when the final recommendations of the Committee are made, it will be found that the Government will be strongly urged to deal at once with the whole subject of Smoke Abatement on a fresh, comprehensive, and National basis. An authoritative recommendation of this kind would give a great impetus to the manufacture and sale of Smoke Abatement, Ventilation and Dust Prevention appliances of every type.

It is thus clear that a Smoke Abatement Exhibition could not be undertaken at a more propitious moment, and the Promoters confidently expect that the present venture will prove to be an immense stimulus to the practical and business sides of the movement.

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